SHORE-BASED BALLAST WATER TREATMENT IN CALIFORNIA

TASK 13: OTHER ANALYSIS AND FINDINGS

PREPARED FOR

DELTA STEWARDSHIP COUNCIL
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Revision History

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References

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Executive Summary

This report examines the concept of a statewide network of mobile treatment barges for receiving and treating ships' ballast water to California's Interim Ballast Water Discharge Performance Standards (CA Interim Standards). This approach, termed "barge-based," is one approach to shore-based ballast water reception and treatment. Shore-based approaches are different than vessel-based approaches where the treatment plants are located onboard the marine vessels (ships) that are carrying ballast water. In the case of mobile treatment barges, the treatment equipment is located on these shore-based mobile barges and not the marine vessels that carry ballast water into port.

Scale-up of Land-based and Barge-based Alternatives (Reference 7), found the barge-based alternative to be "significantly more economical than the land-based alternative in terms of capital, operating, and life-cycle costs." That analysis applied the findings and data from the Task 2-5 work effort to two different California port districts. In addition to cost advantage, the barge-based alternative offered more technical certainty. The Delta Stewardship Council review panel concurred with this assessment and directed that further shore-based analysis be dedicated to the barge-based alternative.

This Task 13 report develops the barge-based concept that was introduced in Reference 7. It provides the basis for the analysis in Tasks 6 through 12.

This report describes one example of how barge networks could be designed, dividing the state into six (6) discrete network service areas or "zones." While other network configurations could ultimately prove more favorable or economical, this configuration is presented as a workable solution. Further research beyond the scope of this study could be performed to determine an optimal network design.

Ballast water treatment services in each zone are provided by an independently operated fleet of tank barges fitted with ballast water treatment systems on the main deck capable of meeting the CA Interim Standards, i.e. ballast water treatment barges (treatment barges).

Within their respective zones, treatment barges would be dispatched directly to marine vessels, at berth or at anchor, planning to discharge ballast water. These barges would be pushed, towed, or otherwise transported by towing vessels (tugs), and secured alongside near a ballast transfer station on the vessel's main deck (Reference 1). A flexible hose would then be lifted by a deck crane on the barge and connected to a presentation flange at the vessel's ballast transfer station for the capture of untreated ballast water. During de-ballasting operations, ballast water would flow into the treatment barge tanks and, from there, a system of pumps would draw it to the main deck for treatment before discharging overboard.

This operation is analogous to ship bunkering operations; and though it would constitute a new operation for ships' crews to manage, the general process would be very similar. Additional training would consist of education on the particulars of off-loading ballast water and, in some cases, handling hoses of significantly larger sizes than are used for bunkering operations. Additional procedures and, potentially, more barge operators maybe needed in cases where ballast transfers would take place simultaneously with cargo operations. Shipboard modifications described in Task 2 would still be required, as with any shore-based treatment approach. The barge network would come online over a five-year period as marine vessels are constructed and outfitted with suitable ballast transfer stations.

Three generic treatment barge concept designs have been developed for use across all six zones, summarized in Table 1. These barge sizes correspond to the range of ballast water discharge volumes and flow rates in California. Employing multiple barge sizes instead of just one standard barge design reduces the overall cost of the statewide fleet, as utilizing smaller barges (whenever they are able to serve all expected ballast water discharges) reduces capital expenses and vessel horsepower/capability requirements.

Table 1 Standardized barge designs for service in California

Treatment Barge Design	Small Barge	Medium Barge	Large Barge
Service Capacity			
Ballast Volume	10,000 m^3	20,000 m^3	35,000 m^3
Particulars			
Length	200 ft	240 ft	280 ft
Breadth	62 ft	74 ft	84 ft
Summary Totals			
Treatment Plant, Rate	721 m^3/hr	1,450 m^3/hr	2,570 m^3/hr
Surge Capacity, Volume	2,789 m^3	5,502 m^3	9,297 m^3
Cost, Barge and Outfitting	$6,273,599	$10,192,858	$15,451,111
Cost, Treatment Plant	$4,609,943	$7,009,470	$9,883,075
Cost, Total	$10,883,542	$17,202,328	$25,334,186

Across the six California treatment zones, there is variation in the size and composition of individual treatment barge fleets. Each fleet is structured to suit the average frequency and volume of ballast water discharges that occur in their respective zones, using some combination of the standardized barge designs introduced above. The composition of treatment barge fleets is summarized below in Table 2. Methods for determining treatment barge fleet composition and detailed information on each zone/fleet is provided in later sections.

Table 2 Treatment barge zone summary

Zone Designation	Service Area	Small Barges (10,000 m^3 service)	Medium Barges (20,000 m^3 service)	Large Barges (35,000 m^3 service)	Total Barges
Zone 1	San Francisco Bay (North Part) and Humboldt Bay	1	1	2	4
Zone 2	San Francisco Bay (South Part) and Monterey Bay	2	-	2	4
Zone 3	Carquinez Strait and Suisan Bay	1	1	2	4
Zone 4	Stockton	-	1	2	3
Zone 5	Los Angeles/Long Beach and Vicinity	3	1	3	7
Zone 6	San Diego	2	-	-	2
TOTALS		**9**	**4**	**11**	**24**

Implementation of a treatment barge network in California requires a business model that balances the competing needs of: a) supporting existing commerce patterns, and b) ensuring investment of significant capital and time into this new and uncertain market. If the resulting fees to vessel operators are too high or imbalanced, it could result in the diversion of marine commerce away from California in general, or a shifting of vessel activity from small or remote

California ports to larger ones with lower overall port call costs. Investment capital and time is at risk due to the potential for political pressure to delay or even cancel implementation, and dependence on the marine vessels themselves to install specialized ballast transfer stations to support ballast water transfer operations.

A public-private partnership (PPP) is a general framework where one or more private companies could work with California to balance these competing needs. Under the Design, Build, Operate (DBO) variation, California could finance the capital investment with private companies designing, building, and operating a fleet of service barges in one or more zones. Ownership of the barges and assets would depend on the terms of the financing. The PPP would require a licensing agreement that offers private operators exclusive access to the respective zone(s) they service. This would protect the joint investment and provide California a mechanism to control fees and potentially support disadvantaged port locations.

Introduction

This report is part of an overall coordinated study evaluating the feasibility of using shore-based mobile or permanent ballast water treatment facilities to meet California's Interim Ballast Water Discharge Performance Standards (CA Interim Standards). This report is presented to the Delta Stewardship Council to meet the objectives of Task 13 – Other analysis and findings. Description of the overall study can be found in Appendix A, along with definitions for terms used in this study.

This report (Task 13) introduces the concept of a statewide network of mobile treatment barges for the provision of ballast water reception and treatment services across the state, and forms the basis for assessments and analyses in Tasks 6-12.

Justification for Focus on Barge-based Treatment

In Tasks 2-5, the study team used location-specific case studies to cover the range of ports and terminals within California. A case study approach allowed the study team to develop and evaluate a specific treatment approach for each case, based on actual berth locations, estimated piping distances, specific water transfer rates and volumes, and applicable regulations, among other tangible aspects. Key findings from the case studies, relevant to port-wide and statewide application are shown in Table 3.

Table 3 Case study findings applicable to port-wide or statewide implementation

Applicability	Finding	Reference
Marine Vessels	Modifications are necessary for both land-based and barge-based reception alternatives.	Task 2, Section 2.2
Ports and Wharves	Retrofitting for land-based reception presents varied and complex interface challenges.	Task 3, Section 3.3.3
Ports and Wharves	Land-based reception costs range between $650,000 and $1,065,000 per berth, with no apparent economies of scale, as per unit costs do not reduce with each berth installation.	Task 3, Section 2.2
Conveyance	Land-based conveyance requires new pipelines, as conveyance via trucks and/or rail is impractical given the volumes of most BW discharges.	Task 4, Section 3.1.2
Conveyance	Barge-based (or ship-based) solutions alone can practically serve offshore de-ballasting locations such as El Segundo Marine Terminal and Pacific Area Lightering. Barge-based solutions can also practically serve port berth locations, such as the LA bulk and cruise ship terminals.	Task 4, Sections 3.4.2 and 3.5.2
Treatment Approach	New wastewater treatment plants (WWTPs) will be required, as existing plants cannot handle the total dissolved solids (TDS) in ballast water, even if blended with existing wastewater streams.	Task 5, Section 5.4

Based on the findings of Tasks 2-5, two shore-based treatment approaches were identified as technically and operationally feasible:

- Centralized land-based treatment ("Land-based"), and
- Mobile barge-based treatment ("Barge-based").

A design installation of each approach paradigm was scaled for two dissimilar California port districts, the Los Angeles/Long Beach (LA/LB) port complex and the Port of Humboldt Bay, and compared in terms CAPEX, OPEX, and total life-cycle costs in a 06 April 2017 project memorandum, titled: *Memorandum on Scale-up of Land-based and Barge-based Alternatives* (Reference 7).

This comparative analysis found that in both the large LA/LB port complex and in Humboldt Bay, the barge-based alternative showed significantly less cost, more economic certainty, and more technical certainty than centralized land-based treatment. Therefore, in order to provide a more detailed analysis of the applicable issues, and a more relevant report for California stakeholders and state policymakers, Tasks 6-13 are focused solely on statewide implementation of barge-based treatment. This approach was supported by the Delta Science program Independent Review Panel for the *Feasibility Study of Shore-Based Ballast Water Reception and Treatment Facilities in California* (Reference 8). This Task 13 report updates the port approach of the Reference 7 scale-up memo to a zone approach capable of serving the entire state. Task 10 updates the estimated costs from the Reference 7 scale-up memo, based on the zone approach and more detailed cost analysis.

Barge-based as a Shore-based Approach

The focus on ***shore-based*** is different than the more common ***vessel-based*** approach where the treatment plants are located onboard the marine vessels (ships) that are carrying ballast water. The ***barge-based*** alternative is a variation on shore-based and discussed in Task 13 and other task reports. In barge-based the treatment equipment is located on a shore-based barge, and not on the marine vessels (ships) that are carrying ballast water into port.

Zone-based Barge Deployment Strategy

With the focus on a barge-based BW treatment approach, the question of how treatment barges will be deployed must be addressed. This study recommends a zone approach, by which California State waters are subdivided into a number of smaller operating zones, with each zone having a dedicated fleet of treatment barges. Having barges dedicated to individual zones will simplify management of vessel operations and ensure quality of service in localized areas.

While other network configurations could ultimately prove more favorable or economical, this configuration is presented as a workable solution. Further research to determine an optimal network design is beyond the scope of this study, but could include the employment of risk analysis methodologies and/or SWOT (strengths, weaknesses, opportunities, threats) analysis.

Ballast water treatment services in each zone would be provided by a dedicated fleet of treatment barges operated by an independent marine contractor. Marine contractors would be responsible for all matters related to the provision of ballast water treatment services in their respective Zone(s), including:

- Vessel scheduling/dispatch.
- Ballast water capture and treatment operations.
- Ballast water filtrate storage and disposal.
- Vessel crewing and crew training.
- Contingency planning.

- Vessel maintenance and inspections (including maintenance of onboard treatment systems).
- Documentation and reporting of pertinent data/information.
- Communication with vessel operators and agents.

In developing a feasible zone approach, a statewide assessment was conducted, broken into four main aspects:

- Develop a defensible method for dividing the state into discrete ballast water treatment zones.
- Determine the geographical boundaries of each zone, as well as any “satellite” areas to be served.
- Determine design basics for a minimum number of treatment barge models needed to efficiently serve all vessel types (i.e. basic dimensions, ballast water storage capacity, and ballast water treatment capacity).
- Use data to determine the total number and appropriate “mix” of treatment barges needed to provide adequate service for each zone.

The results of this assessment are described in later sections of this report.

Operating and Governance Model Considerations

The concept of barges serving larger marine vessels is centuries old. In California presently, fleets of barges compete to service oceangoing vessels, primarily for the provision of fuel oil bunkers. While it may be reasonable for such fleets to expand to meet the ballast water reception/treatment market, it is proposed for costing purposes that California finance the construction of new treatment barges and grant exclusive operating licenses on a duration and zone basis. For this new market, this is proposed as most likely to gain commercial participants.

Summary of Findings

The use of treatment barges offers an effective means of servicing all ports and outport locations in California. These barges can be effectively dispersed throughout port districts to ensure vessels can offload ballast water at their current ballast water discharge rates. There are several commercial approaches to implementing such a network of barges, with a concession, granted for a limited time on a per-zone basis, suggested as a means to promote effective service and pricing.

Data Description and Methods

The National Ballast Information Clearinghouse (NBIC), a joint program of the Smithsonian Environmental Research Center (SERC) and the United States Coast Guard (USCG), provides an online tool to access ballast water management reports from all vessels reporting in the United States (Reference 5). Ballast water discharge activity in California waters was characterized by NBIC data exclusively.

Quality Control

All data entered into the NBIC database undergoes extensive quality control checks to ensure reporting data field accuracy, but does not otherwise include verification of regulatory compliance. According to the NBIC, their quality assurance measures include direct communication with ballast water management report submitters. When direct communication results in the need for a corrected form to be submitted, the NBIC replaces the originally submitted data with corrected data in their database. For this analysis, additional quality checks were not performed by Glosten and the data was used as-is.

Approach

Vessel arrivals and ballast tank detail data were downloaded from the NBIC website in the form of comma-separated values (CSV) files for vessels arriving in California for years 2011 to 2015. The ballast tank detail data only were used to characterize ballast water discharge activity in California.

Ballast water discharge activity was analyzed per zone. Ballast water discharge activity within a zone was defined as all discharges that had discharge locations reported at ports or anchorages within the zone, regardless of arrival port and ballast water management. Discharge locations that were recorded as latitude/longitude or a place name not in the list of commonly used California discharge locations were neglected. Further analysis on these discharge events would be required to determine if they did fit into one of the zones defined here. Over the five years examined, discharges at locations that were recorded as such amounted to 4% of all discharges by volume.

The ballast tank detail data records reflect the tank-by-tank discharge activity reported on each ballast water management report submitted. This level of granularity was not required for the analysis performed here. To consolidate the tank-by-tank data into single discharge events, each record was assigned a unique identifier composed of the vessel's IMO number, discharge date, and an identification number associated with the discharge location. A ballast discharge event was then defined as a group of records with the same unique identifier.

Tools

Microsoft Excel (2013) was used to process the NBIC data.

Ballast Water Treatment Barge Design Basis

The treatment barge concept design is based on the ability of the barge to receive, treat, and discharge ballast water discharged from a marine vessel. The concept looks to minimize impacts to existing operations (allowing the marine vessel to maintain its current discharge frequency, location, and rate) and treat ballast water to the CA Interim Standards. Three different barge sizes have been developed based on various ballast water discharge rates and volumes from marine vessels.

General Requirements

The treatment barge includes both a ballast water treatment system on the main deck and ballast water storage below the main deck in the barge hull. Ship connection equipment, ballast water treatment system equipment, and auxiliary support systems, such as electrical power generation, will be located on the treatment barge. The required footprint areas for these systems will be determined during detailed barge design efforts. Preliminary estimates of required treatment capacity and associated deck areas have been conducted as part of Task 4 and Appendix 6. These BW treatment capacity/deck area estimates have been scaled for various barge dimensions.

The treatment barges have been sized to have double-hulls, meaning two watertight boundaries separated by a void space (i.e. and inner hull and outer hull) between the contents of the tanks and the ambient water, to reduce the likelihood of spills. It is possible to reduce the barge cost if a single hull construction is considered, especially noting that untreated ballast water in significant quantities would normally only be onboard during the treatment process.

No single-purpose barges, such as a dedicated storage-only barge or a dedicated treatment-only barge, are under consideration, though it is possible that future research could identify a need for such barges for system optimization. System optimization is outside the scope of this feasibility study.

The following requirements will be applied to all treatment barges, regardless of size or BW treatment capacity:

- Two BW transfer stations shall be provided, one port and one starboard to receive BW from marine vessels. These shall be located in a position for ready access to hoses or mechanical arms provided by shore-based services, i.e. near the sideshell on the main deck.
- One deck crane will be provided, with capacity to serve port and starboard BW transfer stations.
- Deckhouse with electrical power generation and support machinery, sized to support the capacity of the BW treatment plant and associated systems.
- On-deck BW treatment plant, sized to support the respective barge size.
- Integrated BW storage tanks and transfer system, sized to support the respective barge size and BW treatment system capacity.
- Towing and mooring equipment to support the respective barge size and deployment requirements.
- Deck lighting and other support systems to support 24/7 operations.

- Perimeter containment coaming and local containment spaces to reduce the probability of spills.

Particulars for Barges and Treatment Plants

Table 4 outlines the preliminary particulars for each of the treatment and storage barges. A notional barge design is shown in Figure 1.

Table 4 Standardized barge designs for service in California

Treatment Barge Design	Small Barge	Medium Barge	Large Barge
Service Capacity			
Ballast Volume	10,000 m^3	20,000 m^3	35,000 m^3
Particulars			
Length	200 ft	240 ft	280 ft
Breadth	62 ft	74 ft	84 ft
Summary Totals			
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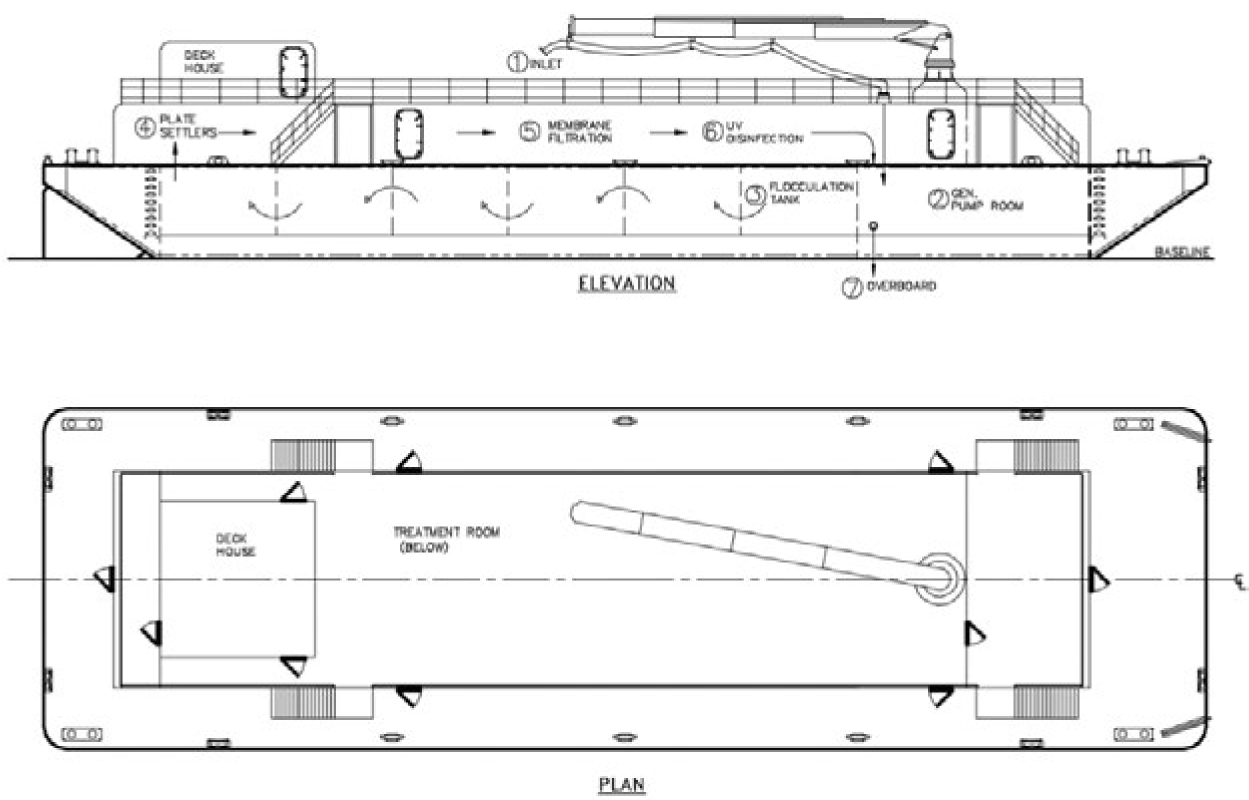


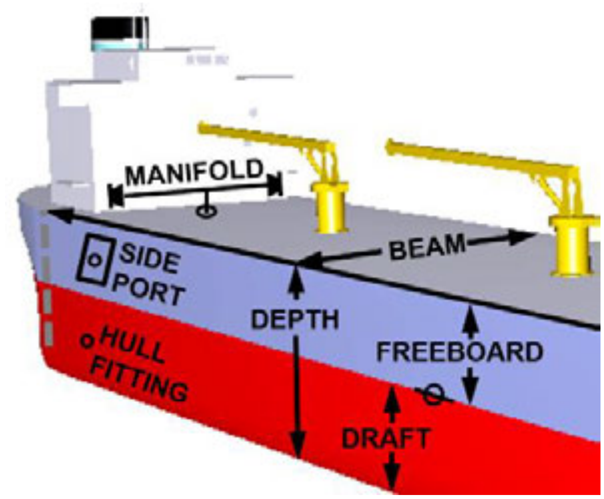
Figure 1 Notional barge design

Ship Connection Options

The offloading of ballast water from a marine vessel to a shore-based facility requires an external connection. There are two primary methods for making such a connection: a new deck or side-hull connection; or, connecting to existing overboard discharge fittings. This study only considers a new deck or side-hull connection, as outlined in the Task 2 report. Making connections to existing overboard fittings is not explored as and the technical feasibility of such connections is unproven. It is not clear that a connection (whether above or below the waterline) can be maintained with zero spillage/leakage of ballast water.

The result of this consideration is that all ships that expect to discharge ballast water must be outfitted with a dedicated hull or side-port connection. This is an "out-of-network" cost that must be borne by individual ship owners or operators. In other words, every ship calling in California would need to install a ballast transfer station to make the treatment barge connection.

Table 5 Ship connection options

Representative Image	Concept
	**<u>Concept Locations for Connection</u>** This image identifies possible locations for capturing ballast water discharges from marine vessels. A **<u>deck manifold</u>** connection is the more obvious location for oil tankers, bulk carriers, containerships, and ATBs. A **<u>side port</u>** connection is likely for car carriers and passenger cruise ships that already use such locations for fuel-oil bunkering operations. The direct use of **<u>existing hull fittings</u>** have been considered for capturing ballast water, avoiding the need to modify the marine vessels. This is not considered as this is experimental at this time.
	**<u>Deck Manifold – Use of Hoses</u>** This image shows a small fuel oil bunker hose connected between a barge and an oceangoing vessel. A new deck connection for ballast water would be required on marine vessels. Hoses are widely used for transfer of liquids between marine vessels and shore facilities. This image likely shows a DIN100 hose transferring fuel oil bunkers. The hose is supported by a boom crane that is lifted high above the hose, in order to relieve stress of the hose fittings and to compensate for relative motions between the two vessels.

Representative Image	Concept
	**Side Port Connection** This image shows a side port on a vehicle carrier engaged in fuel-oil bunkering operations. Side ports for fire, sewage, and fuel oil bunker connections commonly exist on passenger cruise ships and vehicle carriers. However, it is on a case-by-case basis if there is adequate room to add an additional connection. Existing lines would need to be refitted to accommodate the additional ballast water connection, or a new side port would be required.
	**Hull Fitting – Capturing Existing Discharge Point** This approach considers capturing ballast water discharge at the overboard discharge hull fitting. In some cases this hull fitting will be above the waterline, as shown in the image to the left. In other cases, the hull fitting will be below the water line. The scale of the ballast water discharge can be seen by the image to the left, as well as how the ballast water discharge spreads over distance. If using the petroleum transfer analogy, it is unlikely that oil products would be transferred by means of a hull fitting. If there is zero tolerance of ballast water spills, then use of a hull connection might not be acceptable. This is not considered at this time, as it is experimental.

General Operating Sequence for Treatment Services

Treatment services for cargo vessels would be provided by a single treatment barge mobilized and secured directly alongside ships at berth or anchor. On rare occasions, for extremely large-volume discharge events, two treatment barges may be required (in sequence) to complete the treatment operation.

Once the treatment barge is correctly spotted (i.e. located) and secured alongside, a deck crane would be used to lift a flexible hose to a ballast transfer station on the ship's main deck (Reference 1). Similar to bunkering operations, the ship's crew would be called upon to bolt the flange of the flexible hose to the ship's presentation flange at the ballast transfer station. A tankerman onboard the treatment barge may inspect the connection prior to the start of ballast water transfer/flow.

At the start of de-ballasting operations, captured ballast water would flow into tanks integrated in the hull of the treatment barge. Treatment would generally not begin immediately, as some minimum water level in the tanks would be required in order to prime the pumps and lift the water to the barge's main deck.

The treatment barge treatment process would follow that of typical shoreside treatment. Figure 1, above, provides a notional arrangement of the typical treatment barge. The treatment process includes flocculation tanks (Step 3 in notional design above), where solids are combined with a flocculent material for ease of separation. Plate settlers (Step 4) collect these solids in a wet slurry. The wet slurry is concentrated by centrifuges with the watery effluent returned to the flocculent tanks and the concentrated slurry stored for later disposal. The separated water stream is then passed through membrane filtration (Step 5) and UV disinfection (Step 6), before being discharged overboard (Step 7).

The resulting treated ballast water would be discharged overboard into the ambient water. Automated real-time monitoring systems and periodic discrete sampling regimes would ensure compliance with local water quality levels.

At the conclusion of the ballast water transfer from the marine vessel to the treatment barge, the transfer hose would be disconnected, shifted back onto the treatment barge, and stowed for next treatment evolution. In this process, both the marine vessel and the treatment barge would need to capture any spillage of ballast water when the connections are made and unmade.

Concept Standard Designs

Ballast water treatment requirements range from several hundred tons or water up to 35,000 MT of ballast water, depending on the size and type of ship under consideration. Within the different treatment zones, there is variability in BWT demands, depending on the type of marine terminals present and the frequency of vessel calls/cargo operations at those terminals.

The use of a limited number of standardized barge designs was determined to be advantageous over multiple custom designs in several respects. Specifically, a set of standardized barge designs serves to:

- Ensure quality and reliability of service within each zone.
- Afford consistency in ballast water treatment operations for vessel operators and deck crews.
- Enhance safety on deck.
- Simplify contingency planning and improve crew preparedness.
- Introduce system (network) redundancy.
- Facilitate system (network) scalability.
- Allow for network adaptability in response to changes in demand (substitution/swapping of vessels between zones).
- Allow for standardized vessel maintenance programs.
- Reduce required inventories of consumables and spare parts.
- Allow for standardized treatment barge crew training programs.
- Reduce timeline for barge construction and delivery (overall system implementation).
- Minimize treatment barge design and construction costs.

Through the data analysis, four logical groupings of ballast water treatment capacities were determined:

- <10,000 MT
- 10,000-20,000 MT
- 20,000-30,000 MT

- >30,000 MT

The NBIC data typically showed decreasing demand as the capacity is increased – i.e. there is more demand for 10,000 MT of treatment capacity than for 20,000 MT, and so on. The data also showed demand seldom exceeded 35,000 MT. This data was then considered in terms of ballast water discharge rates. In other words, 30,000 MT discharged in 24 hours is similar to 15,000 MT discharged in 12 hours. The analysis identified that three standardized barge designs, based on the following 12 hour treatment capacities, could service all California ports:

- 10,000 MT/12-hour treatment capacity.
- 20,000 MT/12-hour treatment capacity.
- 35,000 MT/12-hour treatment capacity.

Three nominal treatment barge designs were developed to suit these three capacities. Treatment barge dimensions are the result of multiple inputs. Accepted design practice and structural design requirements dictate standard barge dimensions in terms of overall length to beam ratios and length to depth ratios. Fabrication considerations and regulations determine the size of the double-hull. Stability requirements and regulations determine the size of rakes on either end of the barge outside the cargo spaces.

Overall limits on maximum barge size are affected by several factors:

- The ability of tugs to safely maneuver and handle the barges alongside ships in the various ports.
- The dimensions of the ports themselves in terms of channel widths and depths when trying to maneuver other vessel traffic around these barges while they are moored to de-ballasting ships.
- Ability to have adequate main deck area for a BWT facility.
- Deadweight capability of barge to hold BW for later treatment.

At this feasibility stage, barge dimensions are merely indicative. Actual barge dimensions would need to be determined during the barge design phase.

Treatment Barge Deployment Strategy and Data Analysis

A zone approach is recommended for the statewide treatment barge network. This section includes the basis of the zone definitions, supporting data analysis to characterize ballast water discharge activity in each zone, and a proposed fleet composition for each zone. The fleet composition within each zone is investigated individually, without considering the ability of adjacent zones to share resources. The analysis includes a redundancy component to allow the consideration of one barge in each zone being out-of-service for maintenance or repair activities.

Zone Definition

Ballast water discharges in the state of California are concentrated in two main areas:

1) The greater San Francisco Bay-Delta area.
2) San Pedro Bay (Ports of Los Angeles and Long Beach) and two nearby offshore areas.

Despite this fact, it is considered impractical to provide state-wide ballast water treatment services with state waters divided into just two subareas. This is largely due to the vastness of the Bay-Delta area, and the scattered distribution of marine terminals from Redwood City, in the south, to West Sacramento, some 100 nautical miles to the north. In terms of ballast water discharges, the Bay-Delta area is characterized by concentrated pockets of activity that are relatively far from one another, making it challenging to provide reliable area-wide service with a single treatment barge fleet. Instead, it is reasonable to divide the area into smaller, more manageable zones, based around these concentrated areas of ballast water discharge activity.

Complicating matters further, there are a number of comparatively small ports along the California coast that see very little in way of ballast water discharge activity but would still require provision of ballast water treatment services. These areas include: Humboldt Bay (Eureka), Moss Landing, Monterey, Morro Bay, Santa Barbara and vicinity, Port Hueneme, and the Channel Islands (namely, Avalon on Santa Catalina Island). San Diego is also an anomaly in that it is a major US seaport, but due to the nature of the vessels and cargoes moving through it, San Diego sees only a small fraction of the ballast water discharge activity occurring in state waters annually.

Another consideration is outlying port districts that might only see an occasional ballast water discharge. It is important to have the flexibility to service these locations, so as to not impede vessel operations.

These matters were taken into careful consideration in determining a feasible zone approach to ballast water treatment in California. Specifically, factors influencing zone designations included:

- Consideration of the practical operating radius of a fleet of treatment barges around a cluster of marine terminals, port district, or geographic area. Zones must be sized such that treatment barges can respond to callouts in a timely fashion, without delaying terminal operations or vessel schedules.
- Concentrated areas of frequent or high-volume ballast water discharges.
- Areas of infrequent or low-volume ballast water discharges.
- Frequency of ballast water discharges in remote ports, such as the Port of Eureka.

- The physical geography of bays, waterways, ports, and harbors, including bridges and other structures.
- Berth density.
- Proximity to other ports or geographic areas.
- Degree of isolation from other ports.

Zone designations were ultimately determined based on the experience and judgement of engineers and marine transportation experts on the project team. The geographical extents, or boundaries, of each zone are not fixed, and should be regarded as illustrative for the purposes of this feasibility study. Further analysis on zone designations is recommended prior to state-wide implementation of barge-based ballast water treatment.

Described below is one network design example, with the state divided into six (6) discrete network service areas, or zones. Other design configurations could ultimately prove more favorable or economical. This configuration is presented as a workable solution for the purposes of this feasibility study. Further research is necessary to determine optimal network design.

In this example, the six (6) network zones are as follows:

- Zone 1 – San Francisco Bay (North Part) and Humboldt Bay
- Zone 2 – San Francisco Bay (South Part) and Monterey Bay
- Zone 3 – Carquinez Strait and Suisan Bay (including Port of Sacramento)
- Zone 4 – Stockton
- Zone 5 – Los Angeles/Long Beach and Vicinity
- Zone 6 – San Diego

Zone boundaries are shown in Figure 2 and Figure 3.

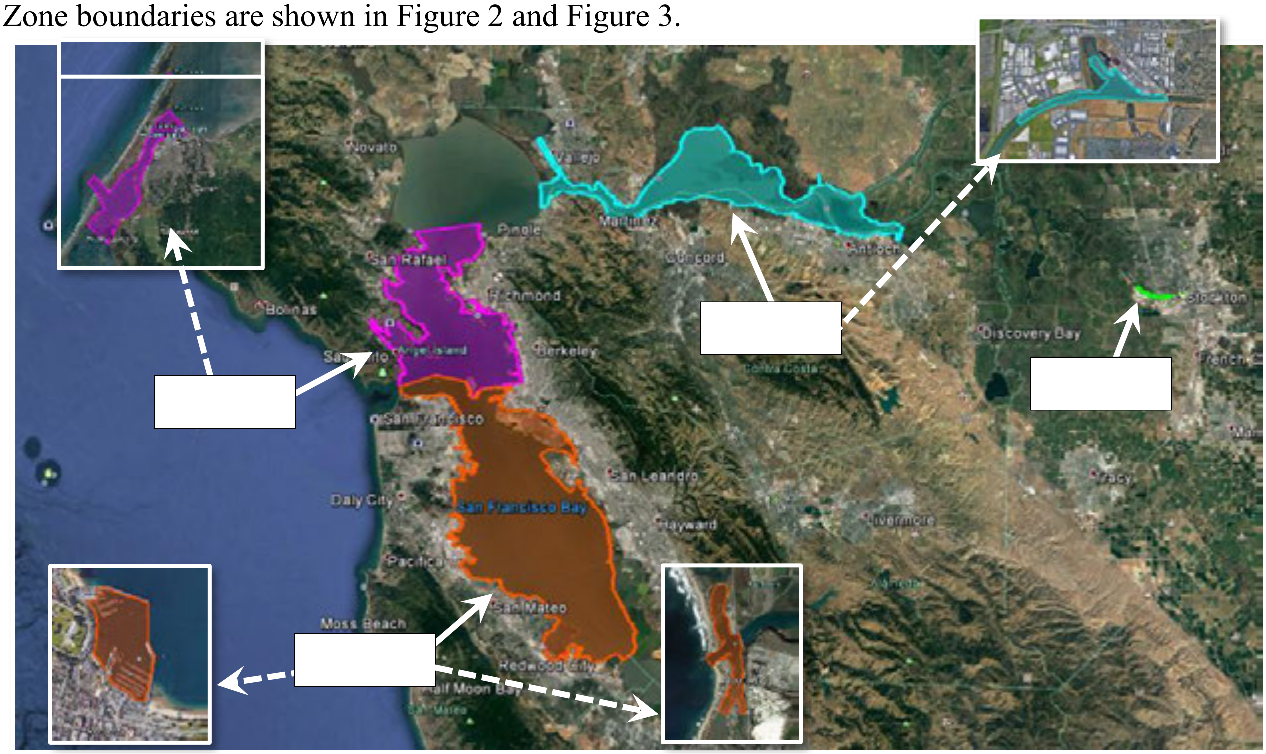


Figure 2 Google Earth capture showing barge network Zones 1-4, with their respective "satellite" areas overlaid

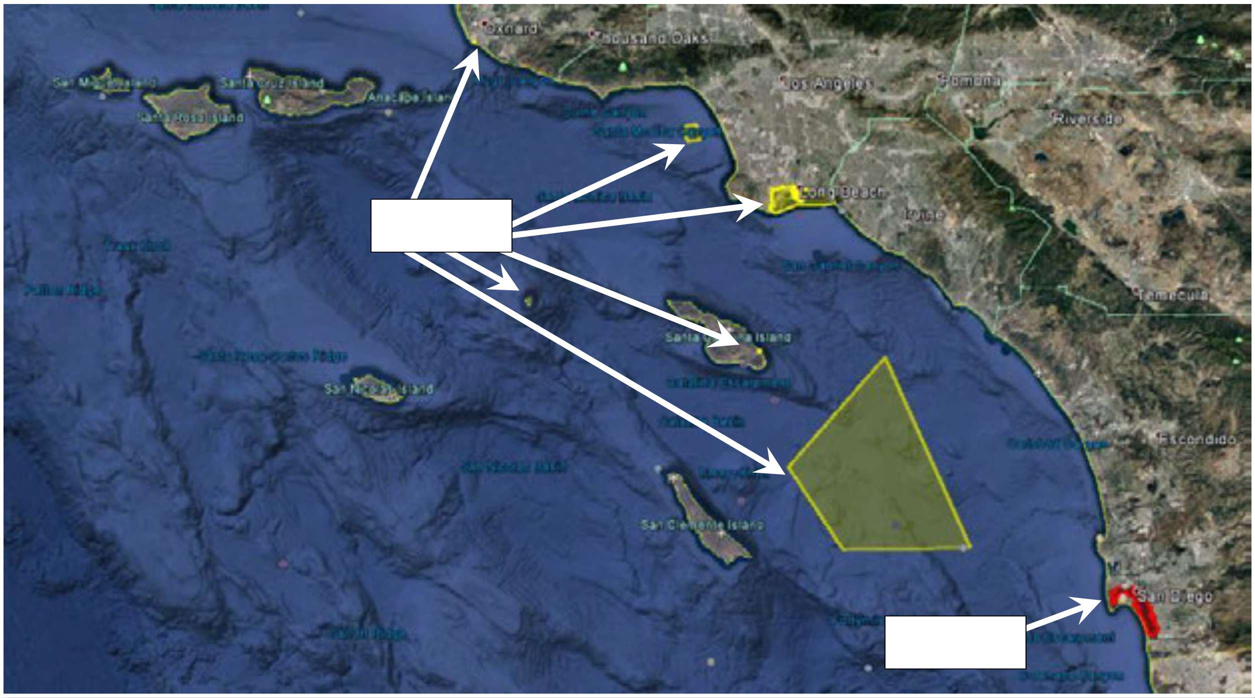


Figure 3 Google Earth capture showing barge network Zones 5 and 6

The ballast water discharge locations from the NBIC data are grouped into these zones as shown in Table 6. All analysis presented in this report reflects this grouping of discharge locations.

Table 6 Zone definition based on NBIC location descriptions

Zone	Discharge Location (NBIC)
1	Eureka (USA, CA)
	Richmond (USA, CA)
	San Rafael (USA, CA)
2	Alameda (USA, CA)
	Monterey (USA, CA)
	Moss Landing (USA, CA)
	Oakland (USA, CA)
	Redwood City (USA, CA)
	San Francisco (USA, CA)
	San Francisco Cotp Zone
3	Antioch (USA, CA)
	Benicia (USA, CA)
	Carquinez (USA, CA)
	Concord (USA, CA)
	Crockett (USA, CA)
	Martinez (USA, CA)
	Pittsburg (USA, CA)
	Rodeo (USA, CA)
	Sacramento (USA, CA)
4	Stockton (USA, CA)

Zone	Discharge Location (NBIC)
5	Avalon (USA, CA)
	Carson (USA, CA)
	El Segundo (USA, CA)
	Lompoc (USA, CA)
	Long Beach (USA, CA)
	Long Beach Anchorage (USA, CA)
	Los Angeles (USA, CA)
	Los Angeles Anchorage (USA, CA)
	Los Angeles- Long Beach Cotp Zone
	Los Angeles-Long Beach (USA, CA)
	Marina Del Rey (USA, CA)
	Morro Bay (USA, CA)
	Newport Beach (USA, CA)
	Pacific Area Lightering (USA, CA)
	Point Arguello (USA, CA)
	Port Hueneme (USA, CA)
	San Clemente Island (USA, CA)
	Santa Barbara (USA, CA)
	Santa Monica Bay (USA, CA)
6	San Diego (USA, CA)

The distribution of ballast water discharges by zone is shown in Figure 4 and Figure 5. Almost half of the average annual discharge volume in California is discharged in Zone 5, which sees an average of over 900 individual discharge events per year. Zones 1, 2, and 3 have comparable discharge volumes and see about the same number of individual discharge events per year.

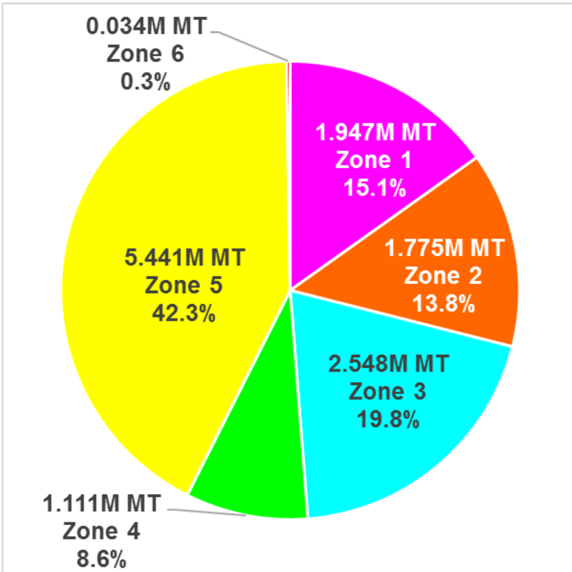


Figure 4 **Annual average ballast water discharge amount by zone based on data from 2011-2015**

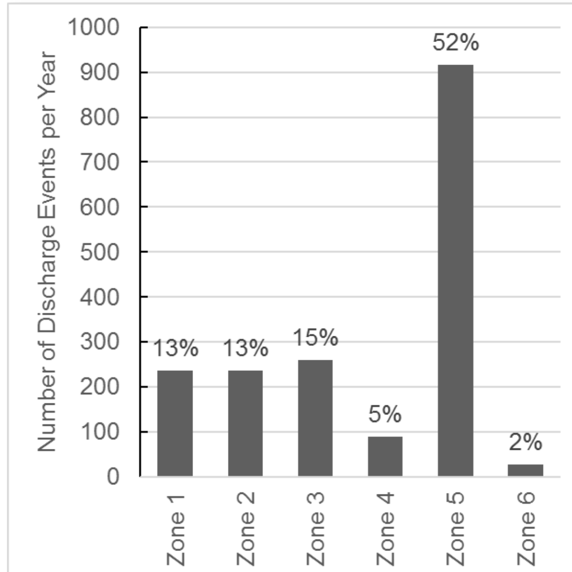


Figure 5 **Annual average number of ballast water discharge events based on data from 2011-2015**

Detailed descriptions of each of the six zones are presented in the following sections.

The treatment barge deployment for the six zones is shown in Table 7. Supporting information for the treatment barge fleet composition for each zone are described in the following sections.

Table 7 **Treatment barge zone summary**

Zone Designation	Service Area	Small Barges (10,000 m^3 service)	Medium Barges (20,000 m^3 service)	Large Barges (35,000 m^3 service)	Total Treatment Barges
Zone 1	San Francisco Bay (North Part) and Humboldt Bay	1	1	2	4
Zone 2	San Francisco Bay (South Part) and Monterey Bay	2	-	2	4
Zone 3	Carquinez Strait and Suisan Bay	1	1	2	4
Zone 4	Stockton	-	1	2	4
Zone 5	Los Angeles/Long Beach and Vicinity	3	1	3	7
Zone 6	San Diego	2	-	-	2
TOTALS		**9**	**4**	**11**	**24**

Robustness of Zone Deployment Strategy

The reliability of the barge-based ballast water treatment approach is maximized with the following features:

- Barge machinery and equipment will be designed to robust marine standards to increase component reliability.
- Redundancy of systems, machinery and equipment on each barge to reduce downtime due to mechanical failure.
- Redundancy in the number of barges assigned to each zone.

  The operational redundancy goal was for a 99% probability of barge availability in each zone, with one barge out of service.
- Barge mobility allows inter-zone asset sharing.

  The mobility of the barges means that a towing vessel and transit time between zones are the only mechanisms required for asset sharing between zones.

The adaptability of the barge-based network is high due to the mobility of barges. Three standard sizes of barges are proposed to meet the system demands as represented by the NBIC data. Should the future demands of individual zones change, barge assets are easily moved from zone to zone to adapt to changes in demand. Should demand increase in any or all zones, additional barges can be constructed to meet increased demand.

The scalability of the barge-based network is high. As individual barges are constructed, they can be placed into operation immediately without having to wait for fixed infrastructure.

Zone 1 – San Francisco Bay (North Part) and Humboldt Bay

Zone 1 encompasses an approximately 92 square mile area of San Francisco Bay, running from the Golden Gate, north of Alcatraz Island, and the eastern portion of the Bay Bridge northward to Pinole Point in San Pablo Bay. The Port of Humboldt Bay is also included in Zone 1 as a satellite service area. The areas of Zone 1 are shown in Figure 6.

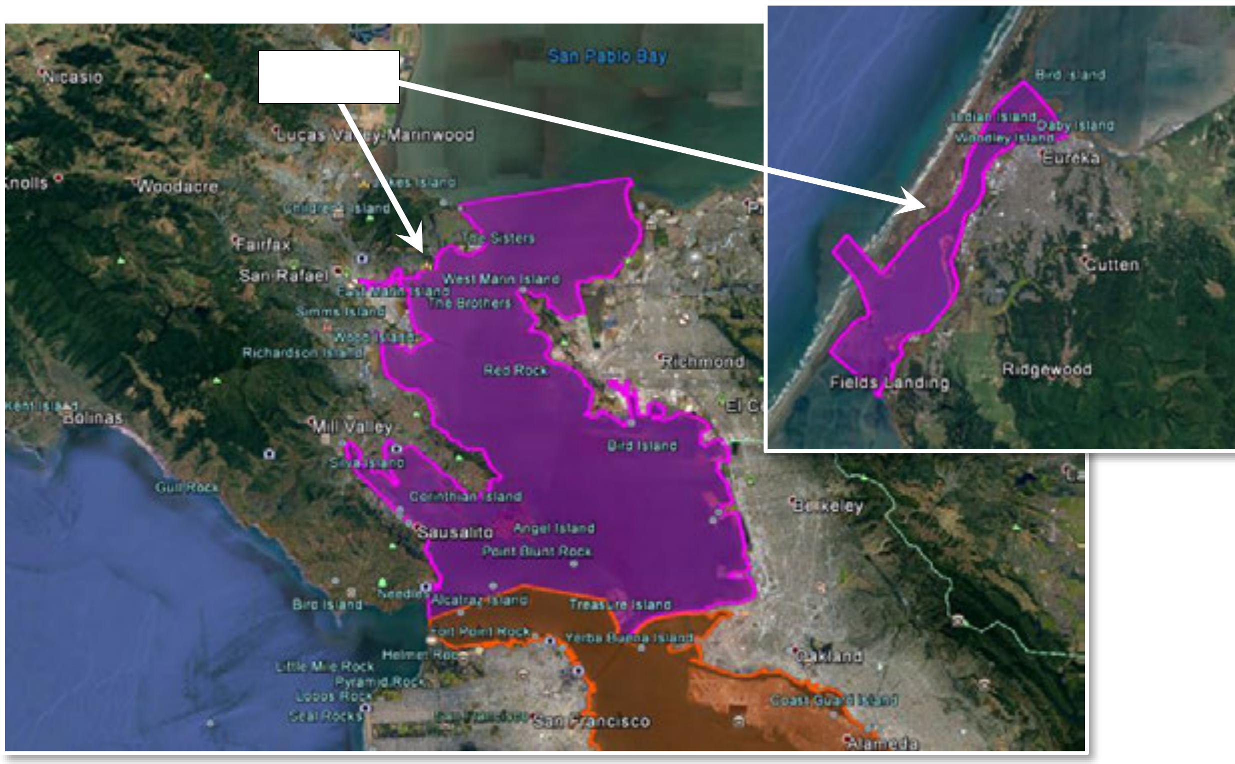


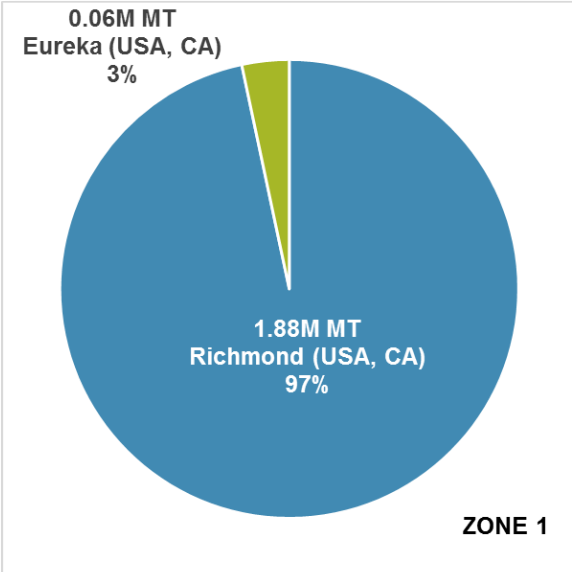
Figure 6 Zone 1 – San Francisco Bay (North Part) and Humboldt Bay

Within Zone 1 are five (5) city-owned terminals and 10 privately-owned terminals in the Port of Richmond, which handle bulk liquids, dry bulk materials, metals, vehicles, and break-bulk cargoes. Included in this group is Richmond Long Wharf, a major tanker terminal operated by Chevron Corporation. Collectively, these terminals move the third largest volume of cargo tonnage in the state of California annually – a total of 19 million short tons. The Port of Richmond also ranks number one among ports in San Francisco Bay for volumes of autos and liquid bulk cargoes (Reference 9).

In the Port of Humboldt Bay, there are eight (8) marine terminals, handling primarily forest products and refined petroleum products (i.e. gasoline and diesel), though shipping activity here is remarkably low in comparison to other “enclosed” deep water bays in California.

Ballast Water Discharge Activity

Ballast water discharge activity in Zone 1 is characterized by the data shown in Figure 7 through Figure 10. Figure 7 shows the distribution of annual average ballast water discharge by discharge location for Zone 1. Only ports with discharge amounts greater than zero are shown. Figure 8 shows the average number of ballast water discharge events per year for each port in Zone 1. It can be seen that 97% of the annual discharge volume in Zone 1 occurs in the Richmond area. Discharges in Humboldt Bay, however, make up only 3%, with discharges occurring about once a month on average.



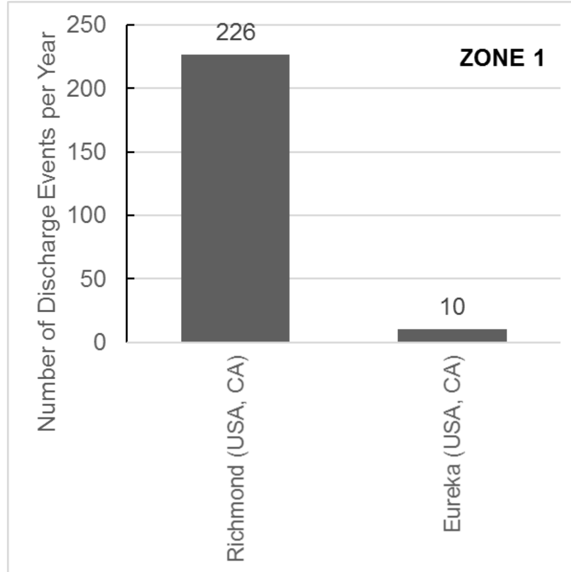
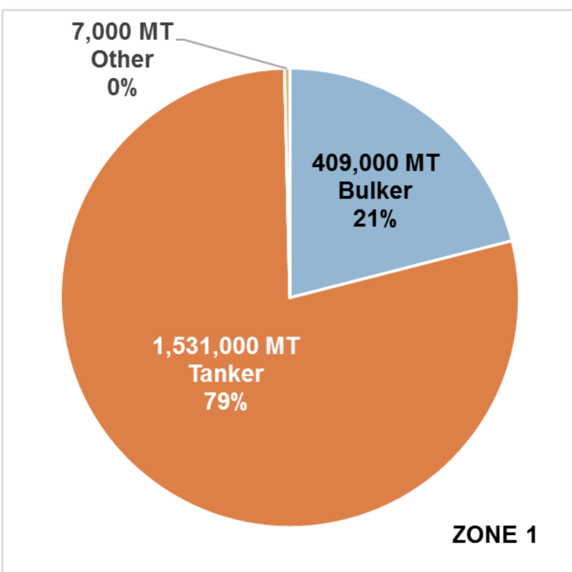


Figure 7 Annual average ballast water discharge amount based on data from years 2011-2015 by discharge location, Zone 1

Figure 8 Average number of ballast water discharge events per year based on data from 2011-2015 by discharge location, Zone 1

Figure 9 shows the annual average ballast water discharge amount in Zone 1 by vessel type, rounded to the nearest 1,000 MT. The ballast water discharge activity in Zone 1 is dominated by tankers. Figure 10 shows the annual average number of discharge events as a function of the amount of ballast discharged during each event. Sixty-six percent of the discharge events per year in Zone 1 are less than 10,000 MT each.



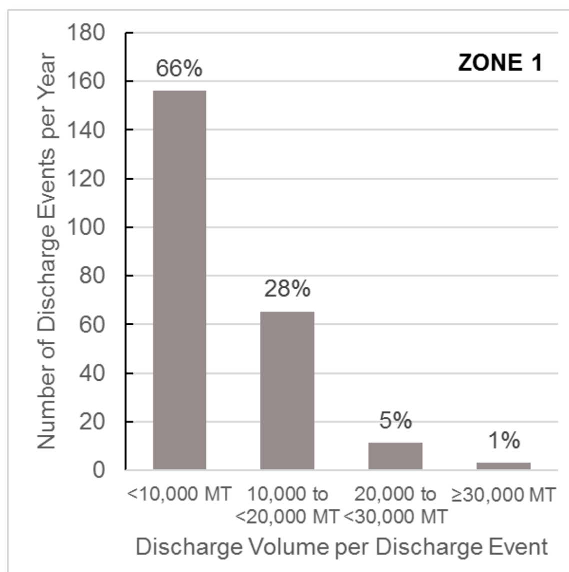


Figure 9 Annual average ballast water discharge amount by vessel type based on data from years 2011-2015, Zone 1

Figure 10 Average number of ballast water discharge events per year as a function of discharge amount based on data from years 2011-2015, Zone 1

The annual daily frequency of discharge events is shown in Table 8 for Zone 1. The annual distribution was determined by averaging the frequency distributions for years 2011 through 2015. On average, ninety-nine percent of the time, or on 364 days of the year, there are three or less discharges per day in Zone 1. Fifty-two percent of the time, or on 190 days of the year on average, there are zero discharge events in Zone 1.

Table 8 Annual average frequency of all discharge events based on data from years 2011-2015, Zone 1

Discharge Events per Day	Number of Days per Year (Cumul. Probability) based on Discharge Volume									
	All Discharges		< 10,000 MT		10,000 - <20,000 MT		20,000 - <30,000 MT		≥30,000 MT	
10	-		-		-		-		-	
9	-		-		-		-		-	
8	-		-		-		-		-	
7	-		-		-		-		-	
6	-		-		-		-		-	
5	-		-		-		-		-	
4	1	(1.00)	-		-		-		-	
3	9	(1.00)	3	(1.00)	0.2	(1.00)	-		-	
2	39	(0.97)	23	(0.99)	5	(1.00)	0.2	(1.00)	-	
1	125	(0.86)	101	(0.93)	54	(0.99)	11	(1.00)	3	(1.00)
0	190	(0.52)	238	(0.65)	305	(0.84)	354	(0.97)	362	(0.99)

Barge Fleet Composition

The barge fleet composition for Zone 1 is shown in Table 9.

Table 9 Treatment barge fleet for Zone 1

Zone Designation	Service Area	Small Barges (10,000 m^3 service)	Mid-size Barges (20,000 m^3 service)	Large Barges (35,000 m^3 service)	Total Treatment Barges
Zone 1	San Francisco Bay (North Part) and Humboldt Bay	1	1	2	4

As can be seen from Table 8, a four-barge system allows for a 99% probability of barge availability with one of the four barges out of service. As can be seen in Figure 10, the vast majority of BW discharge events are for less than 10,000 MT, which can be serviced by any of the barges. While there is little demand for the large treatment barge, as Zone 1 sees about 14 discharge events of over 20,000 MT annually, the large barges are able to service all anticipated BW discharge events. Therefore, to achieve the desired 99% probability of a barge being available with one barge out of service, two large barges are required.

Barge Deployment

The terminals in the Port of Richmond, which compose nearly the entirety of commercial ship berths in Zone 1, are located within a less than two nautical mile radius around Point Richmond, encompassing the Port of Richmond Inner Harbor and Richmond Long Wharf. Given the relative proximity of these terminals to one another, it is expected that the treatment barges assigned to Zone 1 would operate primarily in this immediate area. That noted, longer transits between berths and/or anchorages would occasionally be required. The longest navigable distance between points in Zone 1 (Treasure Island to Pinole Point) is 15 nautical miles, running north-south. At an assumed towing speed of 8 knots, the expected transit time between these points is approximately 2 hours, barring any delays.

To avoid the need for permanently stationed treatment barge in Humboldt Bay, which would sit idle most of the year, a treatment barge would be dispatched and towed from San Francisco Bay to Humboldt Bay for anticipated ballast water discharge events – a distance of roughly 250 nautical miles in each direction – on an as-needed basis. At an assumed towing speed of 8 knots, the expected transit or lead time to provide ballast water treatment services in Humboldt Bay is approximately 1.5 days in favorable conditions. Transits would likely take longer during periods of foul weather or high seas, which can reduce towing speed and, on occasion, render the Humboldt Bay Bar impassable.

Given the uncertainty in transit times between San Francisco Bay and Humboldt Bay, and uncertainty in the duration of cargo operations and related ballast water discharges, it is estimated that treatment barge callouts to Humboldt Bay could take one barge out of service in Zone 1 for periods of 5-12 days.

Zone 2 – San Francisco Bay (South Part) and Monterey Bay

Zone 2 encompasses an approximately 200 square mile area of San Francisco Bay, running from the Golden Gate, north of Alcatraz Island, and the eastern portion of the Bay Bridge southward to Redwood City and the southern extent of San Francisco Bay. Ports within this zone include: Alameda, Oakland, Redwood City, and San Francisco. Zone 2 can be described as a large but contained geographic area with marine terminals concentrated primarily at the northern end (San Francisco, Oakland, and Alameda). Zone 2 is shown in Figure 11.

Figure 11 Zone 2 – San Francisco Bay (South Part) and Monterey Bay "satellite" areas

Within Zone 2 are numerous container terminals, one combination container/Ro-Ro terminal, and one scrap steel terminal in the Port of Oakland. The Port of Oakland loads and discharges more than 99 percent of the containerized goods moving through Northern California and ranks as the fifth busiest container port in the US (Reference 10). Also located in Zone 2 are two cruise ship terminals, a Ro-Ro auto-processing terminal, and five deep water berths in the Port of San Francisco. Of the latter, only Piers 92 and 94 are actively used – generally for importing sand and aggregates to support large-scale construction projects underway in San Francisco and the region (Reference 11). General Anchorages No. 8 and No. 9 are also used regularly for tank vessel and bulk carrier lightering operations, and by vessels awaiting a berth in Richmond or Carquinez Strait.

Collectively, these terminals and anchorages see the bulk of ballast water discharge activity in Zone 2, with 217 discharge events per year on average, and 93 percent of the total volume (see Figures 18 and 19).

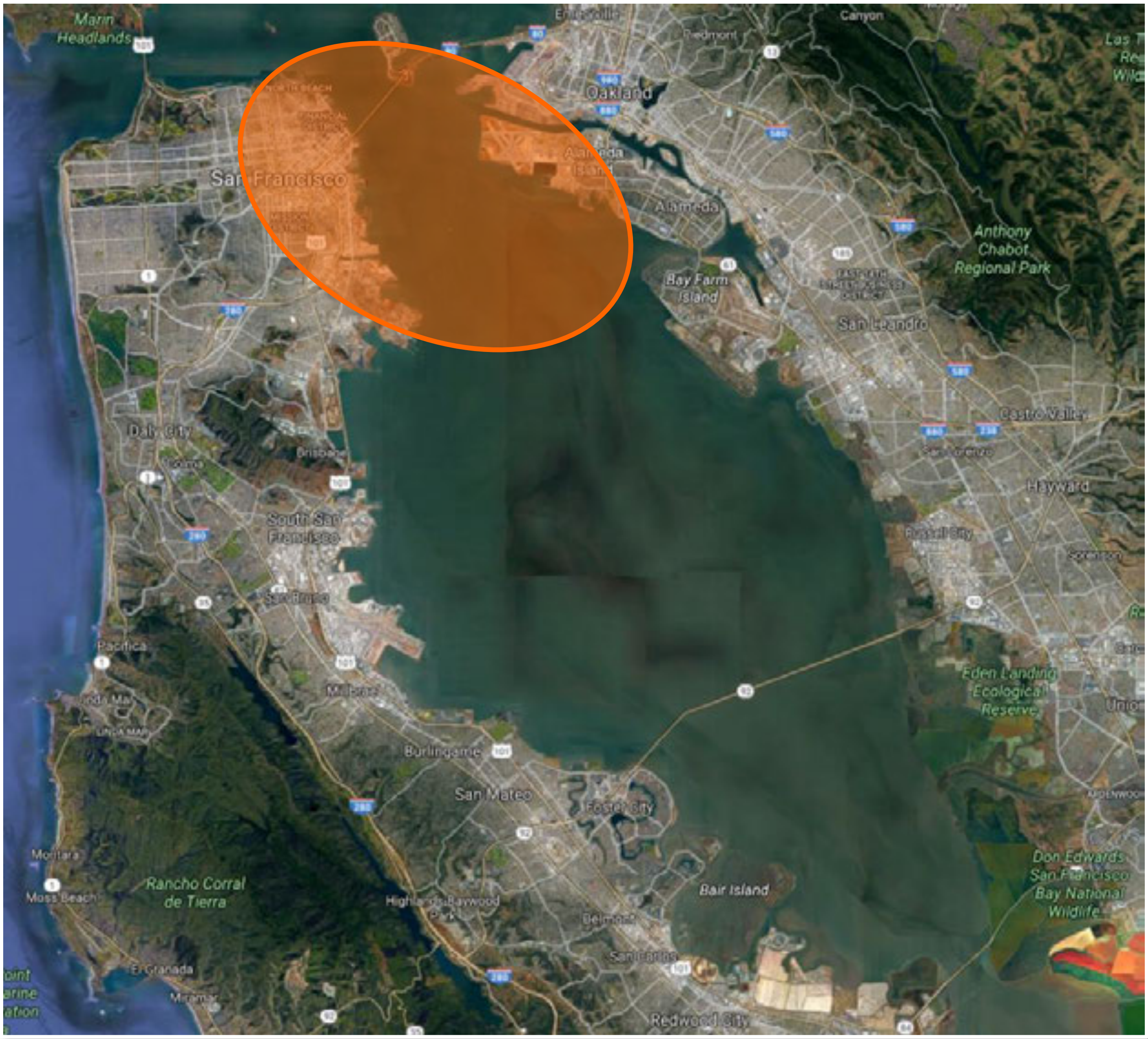


Figure 12 Area of concentrated ballast water discharge activity in Zone 2

Figure 12 shows the general area within Zone 2 where this ballast water discharge activity is concentrated, encompassing General Anchorages No. 8 and No. 9.

Approximately 18 nautical miles south of this area is the Port of Redwood City, which handles bulk, neo-bulk, and liquid bulk cargoes at three neighboring terminals in Redwood Creek Channel. Redwood City is the only deepwater port in south San Francisco Bay, and the only other area within Zone 2 that sees regular ballast water discharge activity (15 discharge events per year, on average) (Figure 13).

Ballast Water Discharge Activity

Ballast water discharge activity in Zone 2 is characterized by the data shown in Figure 13 through Figure 16. Figure 13 shows the distribution of annual average ballast water discharge by discharge location for Zone 2. Only ports with discharge amounts greater than zero are shown. Figure 14 shows the average number of ballast water discharge events per year for each port in Zone 2. It can be seen that 93% of the annual discharge volume in Zone 2 occurs in the Oakland and San Francisco areas, with the remaining 7% occurring in Redwood City.

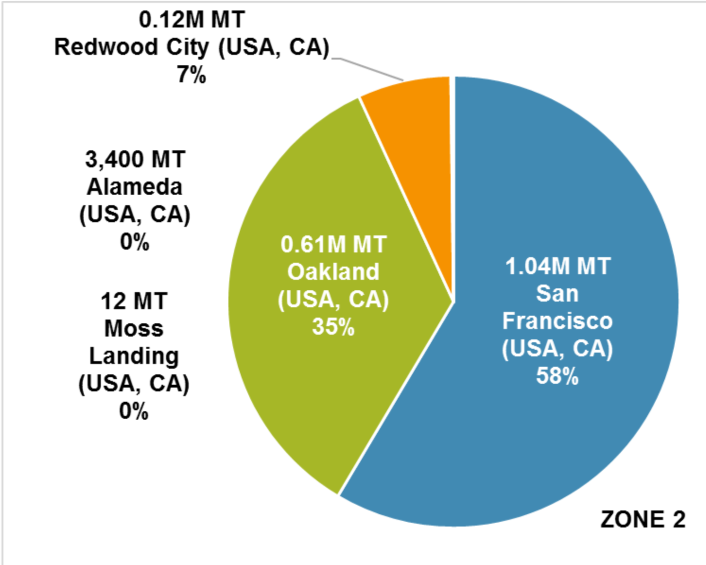


Figure 13 Annual average ballast water discharge amount based on data from years 2011-2015 by discharge location, Zone 2

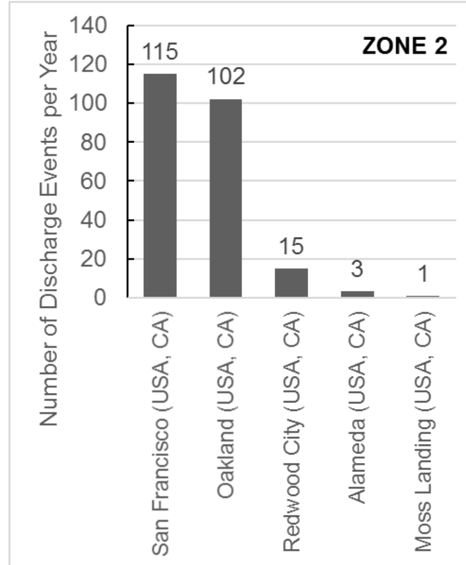


Figure 14 Average number of ballast water discharge events per year based on data from 2011-2015 by discharge location, Zone 2

Figure 15 shows the annual average ballast water discharge amount in Zone 2 by vessel type, rounded to the nearest 1,000 MT. Eighty-four percent of annual ballast water discharge by volume in Zone 2 is shared by tankers and bulkers. Figure 16 shows the annual average number of discharge events as a function of the amount of ballast discharged during each event. Sixty-nine percent of the discharge events per year are less than 10,000 MT each.

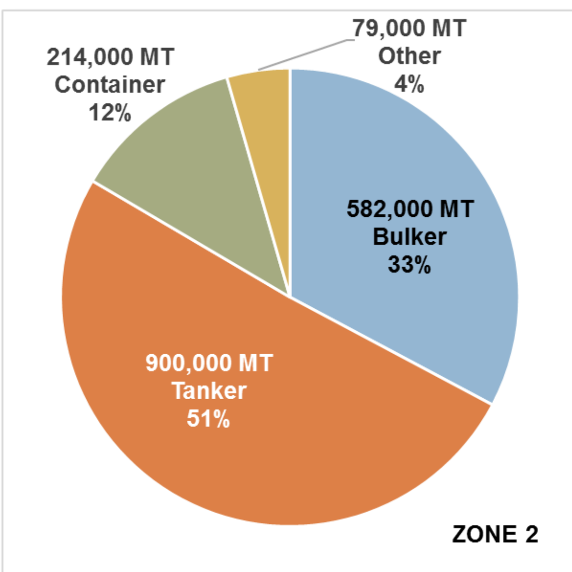


Figure 15 Annual average ballast water discharge amount by vessel type based on data from years 2011-2015, Zone 2

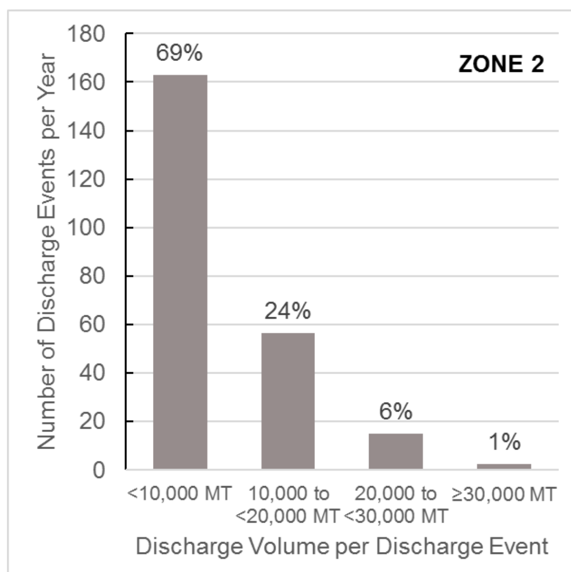


Figure 16 Average number of ballast water discharge events per year as a function of discharge amount based on data from years 2011-2015, Zone 2

The annual daily frequency of discharge events is shown in Table 10 for Zone 2. The annual distribution was determined by averaging the frequency distributions for years 2011 through

2015. On average, ninety-nine percent of the time, or on 364 days of the year, there are three or less discharges per day in Zone 2. Fifty-two percent of the time, or on 189 days of the year on average, there are zero discharge events in Zone 2.

Table 10 Annual average frequency of all discharge events based on data from years 2011-2015, Zone 2

Discharge Events per Day	Number of Days per Year (Cumul. Probability) based on Discharge Volume				
	All Discharges	< 10,000 MT	10,000 - <20,000 MT	20,000 - <30,000 MT	≥30,000 MT
10	-	-	-	-	-
9	-	-	-	-	-
8	-	-	-	-	-
7	-	-	-	-	-
6	-	-	-	-	-
5	0.2 (1.00)	-	-	-	-
4	1 (1.00)	0.4 (1.00)	-	-	-
3	8 (1.00)	3 (1.00)	0.2 (1.00)	-	-
2	40 (0.97)	25 (0.99)	4 (1.00)	0.2 (1.00)	-
1	127 (0.86)	102 (0.92)	49 (0.99)	14 (1.00)	2 (1.00)
0	189 (0.52)	235 (0.64)	313 (0.86)	351 (0.96)	363 (0.99)

Barge Fleet Composition

The barge fleet composition for Zone 2 is shown in Table 11.

Table 11 Treatment barge fleet for Zone 2

Zone Designation	Service Area	Small Barges (10,000 m^3 service)	Mid-size Barges (20,000 m^3 service)	Large Barges (35,000 m^3 service)	Total Treatment Barges
Zone 2	San Francisco Bay (South Part) and Monterey Bay	2	-	2	4

As can be seen from Table 10, a four-barge system allows for a 99% probability of barge availability with one of the four barges out of service. As evident in Figure 16, the vast majority of BW discharge events are for less than 10,000 MT, which can be serviced by any of the barges. While there is little demand for the large treatment barge, as Zone 2 sees about 16 discharge events of over 20,000 MT annually, the large barges are able to service all anticipated BW discharge events. Therefore, to achieve the desired 99% probability of a barge being available with one barge out of service, two large barges are required. Figure 17, below, shows the distribution of these discharges by specific ports in the zone.

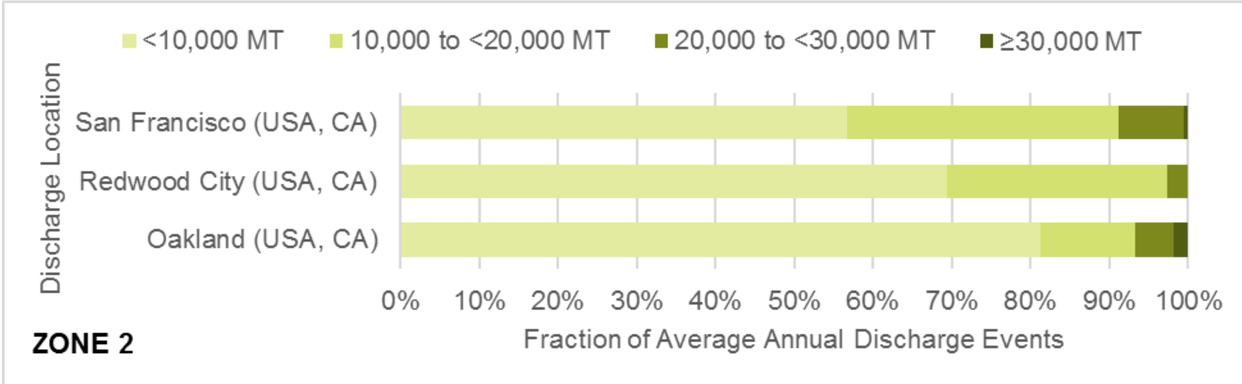


Figure 17 Average annual distribution of discharge events as a function of discharge amount per discharge location based on data from years 2011-2015, Zone 2

Barge Deployment

More than ninety percent of ballast water discharges by volume in Zone 2 occur in San Francisco and Oakland; therefore, it is expected that treatment barges assigned to this zone would operate primarily in this immediate area. That noted, longer transits to/from Redwood City would be required on occasion. The longest expected transit, between berths in Redwood City and North Point, San Francisco, is 23 nautical miles. At an assumed towing speed of 8 knots, the expected transit time between these points is approximately 3 hours, barring any delays.

To avoid the need for permanently stationed treatment barge in Monterey Bay, which would sit idle most of the year, it is assumed that Zone 2 would also service the ports of Monterey and Moss Landing on an as-needed basis. Treatment barges would be dispatched and towed from San Francisco Bay to Monterey Bay for anticipated ballast water discharge events – a distance of roughly 90 nautical miles in each direction.

At an assumed towing speed of 8 knots, the expected transit or lead time to provide ballast water treatment services in Monterey Bay is approximately 12 hours in favorable conditions. Transits would likely take longer during periods of foul weather.

Given the uncertainty in transit times between San Francisco Bay and Monterey Bay, and uncertainty in the duration of ballast water discharge events, it is estimated that treatment barge callouts to Monterey Bay could take one barge out of service in Zone 2 for periods of 2-5 days.

Zone 3 – Carquinez Strait and Suisun Bay

Zone 3 encompasses an approximately 81 square mile area of Carquinez Strait and Suisun Bay, running from Rodeo and Mare Island at the head of San Pablo Bay eastward to the Antioch Bridge. Ports within this zone include: Antioch, Benicia, Carquinez, Concord, Crockett, Martinez, Pittsburg, Rodeo, Selby, and Vallejo. Zone 3 can be described as a ribbon of geographically dispersed marine terminals, handling mostly dry and liquid bulk products/commodities (e.g. crude oil, refined petroleum products, petroleum coke, sulfur, and coal), including multiple oil refineries and related oil terminals.

Zone 3 also includes six (6) ship berths in the Port of West Sacramento (a “satellite” service area), which handle an array of bulk and break-bulk cargoes, including: agricultural produce; forest products; cement, fertilizers, mineral ores and other industrial materials; heavy machinery and equipment; and project cargoes. For marine vessels, the Port of West Sacramento is accessed via the 40-mile-long Sacramento River Deep Water Ship Channel, which connects to the east end of Suisan Bay near Pittsburg.

The areas of Zone 3 are shown in Figure 18.

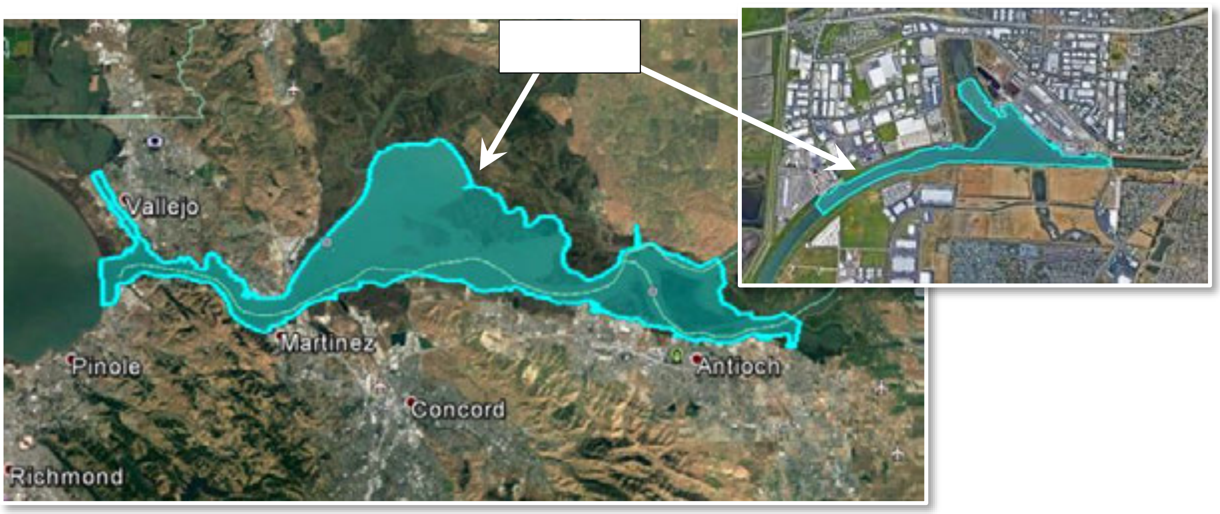


Figure 18 Zone 3 – Carquinez Strait and Suisun Bay and Port of Sacramento

Ballast Water Discharge Activity

Ballast water discharge activity in Zone 3 is characterized by the data shown in Figure 19 through Figure 22. Figure 19 shows the distribution of annual average ballast water discharge by discharge location for Zone 3. Only ports with discharge amounts greater than zero are shown. Discharge locations in the “Other” category include Carquinez, Crockett, and Concord. Figure 20 shows the average number of ballast water discharge events per year for each port in Zone 3. It can be seen that the Port of Martinez sees the greatest number of ballast water discharge events annually, but nearly the same annual discharge volume as the Port of Pittsburg.

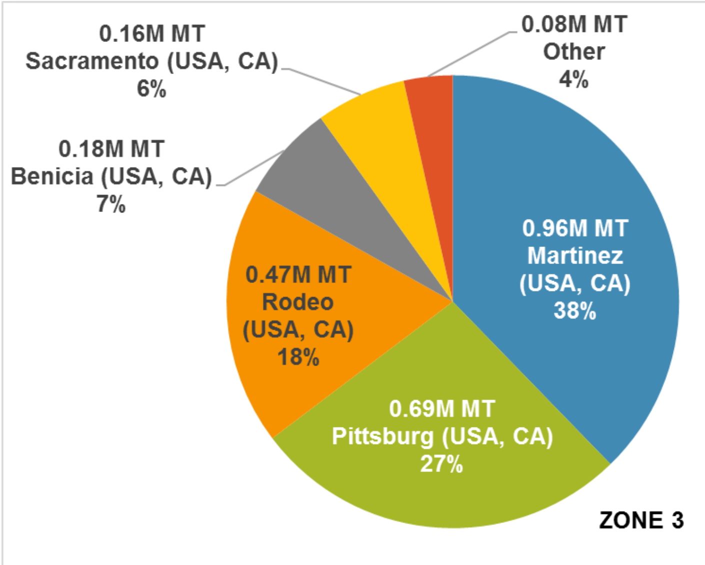


Figure 19 Annual average ballast water discharge amount based on data from years 2011-2015 by discharge location, Zone 3

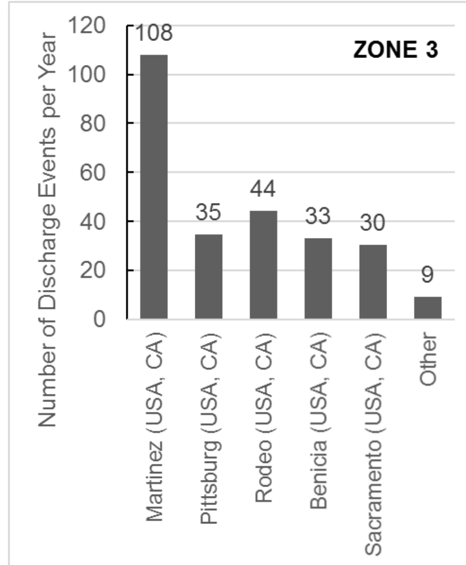


Figure 20 Average number of ballast water discharge events per year based on data from 2011-2015 by discharge location, Zone 3

Figure 21 shows the annual average ballast water discharge amount in Zone 3 by vessel type, rounded to the nearest 1,000 MT. Eighty-two percent of annual ballast water discharge by volume in Zone 3 is shared by tankers and bulkers. Figure 22 shows the annual average number of discharge events as a function of the amount of ballast discharged during each event. Fifty-eight percent of the discharge events per year are less than 10,000 MT each.

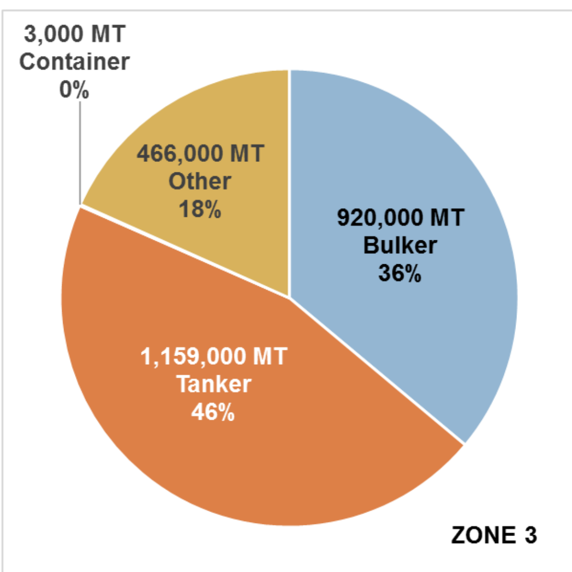


Figure 21 Annual average ballast water discharge amount by vessel type based on data from years 2011-2015, Zone 3

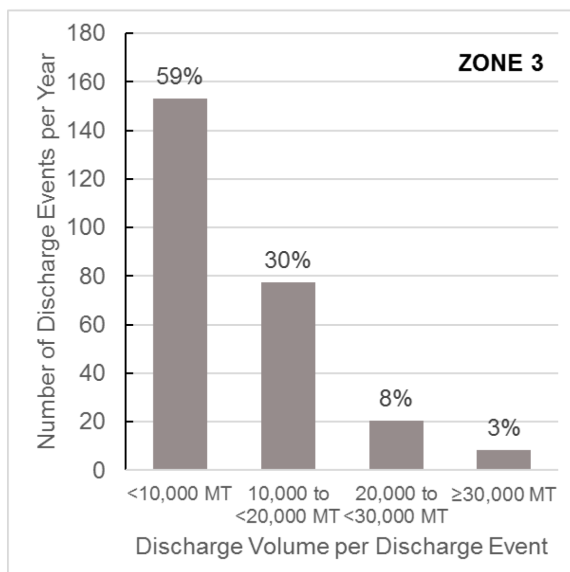


Figure 22 Average number of ballast water discharge events per year as a function of discharge amount based on data from years 2011-2015, Zone 3

The annual daily frequency of discharge events is shown in Table 12 for Zone 3. The annual distribution was determined by averaging the frequency distributions for years 2011 through

2015. On average, ninety-nine percent of the time, or on 363 days of the year, there are three or less discharges per day in Zone 3. Forty-eight percent of the time, or on 176 days of the year on average, there are zero discharge events in Zone 3.

Table 12 Annual average frequency of all discharge events based on data from years 2011-2015, Zone 3

Discharge Events per Day	Number of Days per Year (Cumul. Probability) based on Discharge Volume				
	All Discharges	< 10,000 MT	10,000 - <20,000 MT	20,000 - <30,000 MT	≥30,000 MT
10	-	-	-	-	-
9	-	-	-	-	-
8	-	-	-	-	-
7	-	-	-	-	-
6	-	-	-	-	-
5	0.2 (1.00)	-	-	-	-
4	2 (1.00)	-	0.2 (1.00)	-	-
3	10 (1.00)	3 (1.00)	1 (1.00)	-	-
2	44 (0.97)	21 (0.99)	6 (1.00)	1 (1.00)	-
1	134 (0.85)	102 (0.93)	63 (0.98)	19 (1.00)	8 (1.00)
0	176 (0.48)	239 (0.65)	295 (0.81)	345 (0.95)	357 (0.98)

Barge Fleet Composition

The barge fleet composition for Zone 3 is shown in Table 13.

Table 13 Treatment barge fleet for Zone 3

Zone Designation	Service Area	Small Barges (10,000 m^3 service)	Mid-size Barges (20,000 m^3 service)	Large Barges (35,000 m^3 service)	Total Treatment Barges
Zone 3	Carquinez Strait and Suisan Bay	1	1	2	4

As can be seen from Table 12, a four-barge system allows for a 99% probability of barge availability with one of the four barges out of service. As can be seen in Figure 22, the majority of BW discharge events are less than 10,000 MT, which can be serviced by any of the barges. Table 12 shows a healthy demand for the medium barge and a modest demand for the large barge. Figure 23, below, shows the distribution of these discharges by specific ports in the zone.

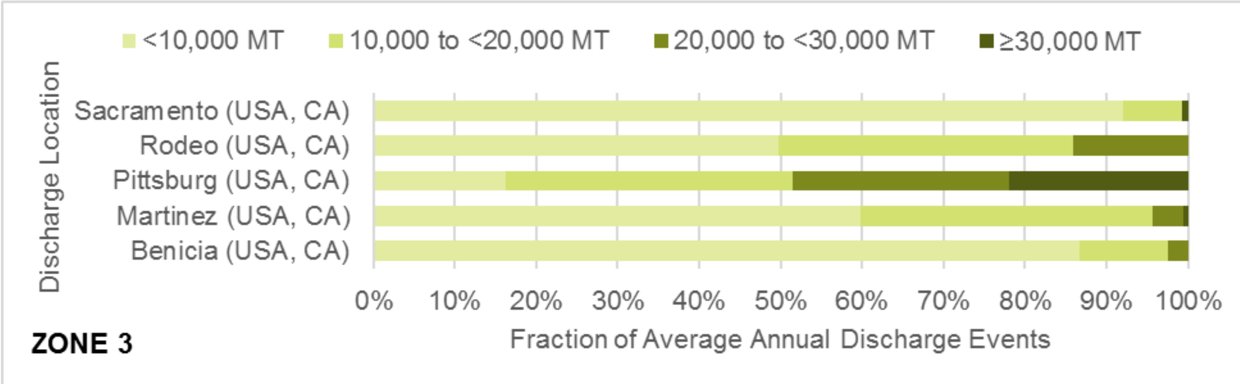


Figure 23 Average annual distribution of discharge events as a function of discharge amount per discharge location based on data from years 2011-2015, Zone 3

Barge Deployment

Ballast water discharges in Zone 3, in terms of volume, are largely split between ports/terminals in Carquinez Strait (mainly Rodeo, Benicia, and Martinez) and Pittsburg at the eastern end of Suisun Bay. Therefore, it is expected that treatment barges assigned to Zone 3 would transit regularly between these two locations. For reference, the distance between the Phillips 66 Marine Terminal in Rodeo and the USS-Posco Terminal in Pittsburg is 20 nautical miles. At an assumed towing speed of 6 knots (due to narrow navigation channels), the transit time between these points is approximately 3.5 hours, barring any delays. That noted, longer transits between berths may be required. The longest distance between points in Zone 3 (Antioch to Rodeo) is 27 nautical miles. At an assumed towing speed of 6 knots, the transit time between these points is approximately 4.5 hours, barring any delays.

To avoid the need for permanently stationed treatment barges in Sacramento, which would sit idle most of the year, it is assumed that Zone 3 would also service the Port of West Sacramento on an as-needed basis. Ballast water discharge events in Sacramento occur 30 times per year, on average - approximately once every two weeks. In such cases, treatment barges would be dispatched and towed, or rather, pushed, from Carquinez Strait/Suisan Bay – a distance of roughly 45 nautical miles (from central Suisan Bay) in each direction. At an assumed towing speed of 6.0 knots, the expected transit or "lead" time to provide ballast water treatment services in Sacramento is estimated at 8 hours; however, transit times in excess of 10 hours are possible if treatment barges are dispatched directly from terminals in the western portion of Zone 3.

Given the uncertainty in transit times between Carquinez Strait/Suisan Bay and Sacramento, and uncertainty in the duration of ballast water discharge events, it is estimated that treatment barge "callouts" to Sacramento could take one barge out of service in Zone 3 for periods of 1.5-4 days.

Zone 4 – Stockton

Zone 4 encompasses an approximately 0.5 square mile area of the San Joaquin River, near Stockton, from the Calaveras River mouth eastward to the Interstate 5 bridge. Considering the geographic isolation of the Port of Stockton relative to Zone 3 (~30 nautical miles from Antioch and ~55 nautical miles from Rodeo), it was determined that this area would be most practically served by a dedicated fleet of treatment barges. Zone 4 is shown in Figure 24.

Figure 24 Zone 4 – Port of Stockton

The Port of Stockton is an important California port for the import and export of bulk products by sea. In 2014, the Port handled nearly 4.1 million metric tons in waterborne tonnage, setting it apart as the leading bulk/break-bulk port in the State. Stockton's marine terminals are divided into two primary berthing "complexes" –the East Complex and West Complex– offering 15 deepwater ship berths, collectively, along a 2.5 mile long section of the San Joaquin River. Also located within the broader port district are a numbr of independently-owned and operated terminals, including the Penny-Newman bulk cargo terminal which handles liquid and dry feed (grain) products (Reference 12).

Ballast Water Discharge Activity

Only the Port of Stockton is located in Zone 4, so ballast water discharge activity in Zone 4 is characterized by the data shown in Figure 25 and Figure 26. Figure 25 shows the annual average ballast water discharge amount in Zone 4 by vessel type, rounded to the nearest 1,000 MT. The ballast water discharge activity in Zone 4 is dominated by bulkers. Figure 26 shows the annual average number of discharge events as a function of the amount of ballast discharged during each event. Fifty-two percent of the discharge events per year are less than 10,000 MT each.

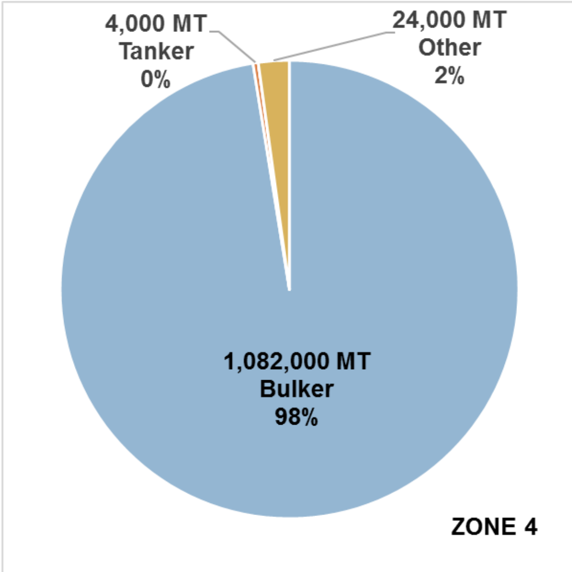


Figure 25 Annual average ballast water discharge amount by vessel type based on data from years 2011-2015, Zone 4

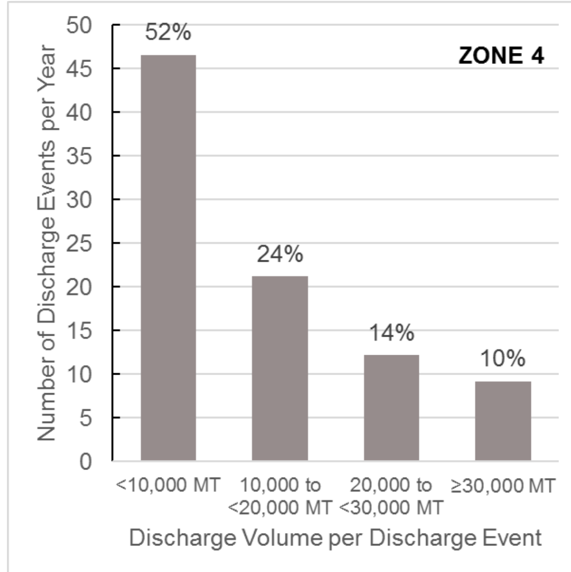


Figure 26 Average number of ballast water discharge events per year as a function of discharge amount based on data from years 2011-2015, Zone 4

The annual daily frequency of discharge events is shown in Table 14 for Zone 4. The annual distribution was determined by averaging the frequency distributions for years 2011 through 2015. On average, ninety-nine percent of the time, or on 364 days of the year, there are two or less discharges per day in Zone 4. In fact, on 283 days of the year on average, there are zero discharge events in Zone 4.

Table 14 Annual average frequency of all discharge events based on data from years 2011-2015, Zone 4

Discharge Events per Day	Number of Days per Year (Cumul. Probability) based on Discharge Volume				
	All Discharges	< 10,000 MT	10,000 - <20,000 MT	20,000 - <30,000 MT	≥30,000 MT
10	-	-	-	-	-
9	-	-	-	-	-
8	-	-	-	-	-
7	-	-	-	-	-
6	-	-	-	-	-
5	-	-	-	-	-
4	-	-	-	-	-
3	0.4 (1.00)	-	-	-	-
2	7 (1.00)	2 (1.00)	0.2 (1.00)	-	0.2 (1.00)
1	75 (0.98)	43 (0.99)	21 (1.00)	12 (1.00)	9 (1.00)
0	283 (0.78)	321 (0.88)	344 (0.94)	353 (0.97)	356 (0.98)

Barge Fleet Composition

The barge fleet composition for Zone 4 is shown in Table 15.

Table 15 Treatment barge fleet for Zone 4

Zone Designation	Service Area	Small Barges (10,000 m^3 service)	Mid-size Barges (20,000 m^3 service)	Large Barges (35,000 m^3 service)	Total Treatment Barges
Zone 4	Stockton	-	1	2	3

While a two-barge system allows for a 98% probability of barge availability with one of the two barges out of service, the goal is 99% probability, therefore a three-barge system is required. As can be seen in Figure 26, the majority of BW discharge events are for less than 10,000 MT, which can be serviced by any of the barges. Table 15 shows a healthy demand for the medium barge and a modest demand for the large barge.

Barge Deployment

Treatment barges assigned to Zone 4 would operate exclusively in this immediate area. The longest navigable distance between points in Zone 4 (Penny-Newman terminal to Berth 20) is 2.5 nautical miles. At an assumed towing speed of 5.0 knots (due to the short transit distance and the constrained nature of the waterway), the expected transit time between these points is approximately 30 minutes, barring any delays.

There are no outports or satellite areas serviced by treatment barges assigned to Zone 4.

Zone 5 – Los Angeles/Long Beach and Vicinity

Zone 5 encompasses an approximately 30 square mile area around the Ports of Los Angeles and Long Beach, and provides service for multiple satellite areas, including Catalina Island (Avalon), El Segundo Marine Terminal and Santa Monica Bay, Pacific Area Lightering (PAL), Port Hueneme, Santa Barbara and vicinity, and Morro Bay. The areas on Zone 5 are shown in Figure 27.

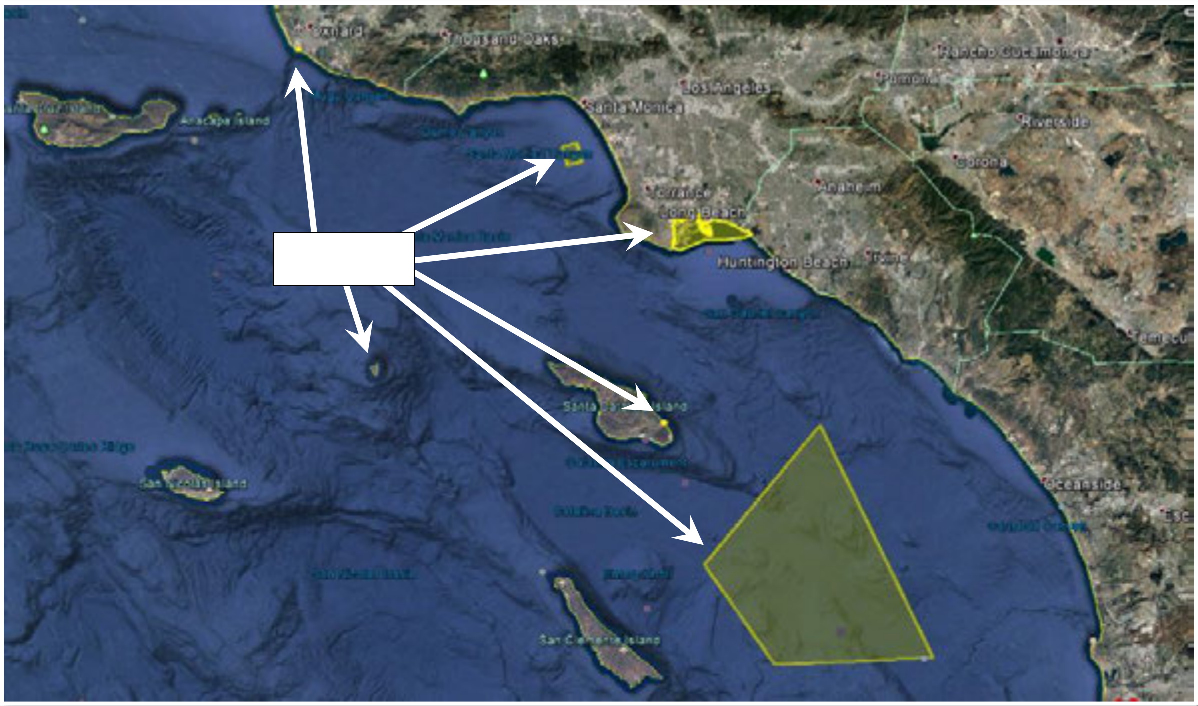


Figure 27 Zone 5 – Los Angeles/Long Beach and Vicinity

Zone 5 differs from all other barge network zones in several important ways.

- As the busiest port complex in the U.S., the average annual number of ballast water discharge events in Zone 5 is greater than that of all other zones combined (see Figure 5).
- The average annual volume of ballast water to be treated in Zone 5 (5.4 million metric tons) more than twice exceeds that of all other zones. This volume of water constitutes 42 percent of the total annual average of ballast water discharged state wide (see Figure 4).
- The requirement to provide ballast water treatment services for two offshore areas roughly 60 nautical miles apart, El Segundo Marine Terminal and PAL, is unique to this zone. This requires specially outfitted barges within the Zone 5 fleet, designated for offshore service.
- Zone 5 is required to provide service for *multiple* satellite areas that do not warrant a dedicated treatment barge fleet of their own and cannot be practically served by treatment barges dispatched from other zones.

These differences add layers of complexity to managing ballast water treatment operations in Zone 5 that make it a special case. These complexities are introduced here, and discussed in more detail in the following Section, "Operational Requirements and Considerations."

Ballast Water Discharge Activity

Ballast water discharge activity in Zone 5 is characterized by the data shown in Figure 28 through Figure 31. Figure 28 shows the distribution of annual average ballast water discharge by discharge location for Zone 5. Only ports with discharge amounts greater than zero are shown. Figure 29 shows the average number of ballast water discharge events per year for each port in Zone 5. It can be seen that the Port of Long Beach sees the greatest number of ballast water discharge events annually, and the Ports of Long Beach and Los Angeles see 82% of average annual ballast water discharge volume.

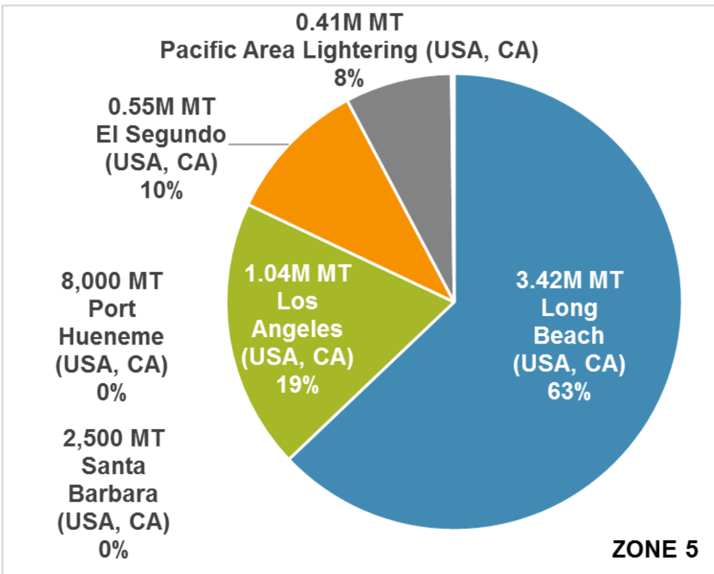


Figure 28 Annual average ballast water discharge amount based on years 2011-2015 by discharge location, Zone 5

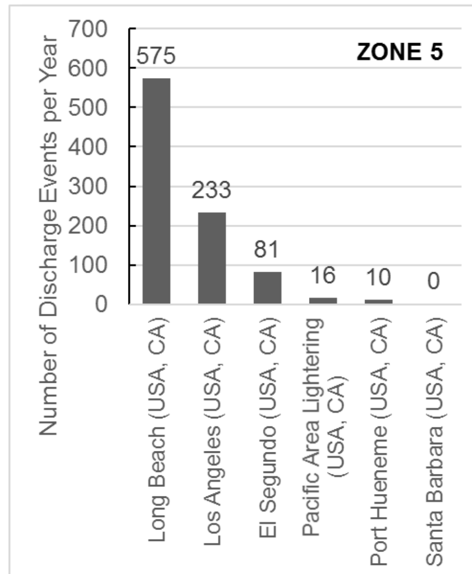


Figure 29 Average number of ballast water discharge events per year based on data from years 2011-2015 discharge location, Zone 5

Figure 30 shows the annual average ballast water discharge amount in Zone 5 by vessel type, rounded to the nearest 1,000 MT. The average is calculated based on data from years 2011 through 2015. Eighty-four percent of annual ballast water discharge by volume in Zone 5 is shared by tankers and bulkers. Figure 31 shows the annual average number of discharge events as a function of the amount of ballast discharged during each event. Seventy-nine percent of the discharge events per year are less than 10,000 MT each.

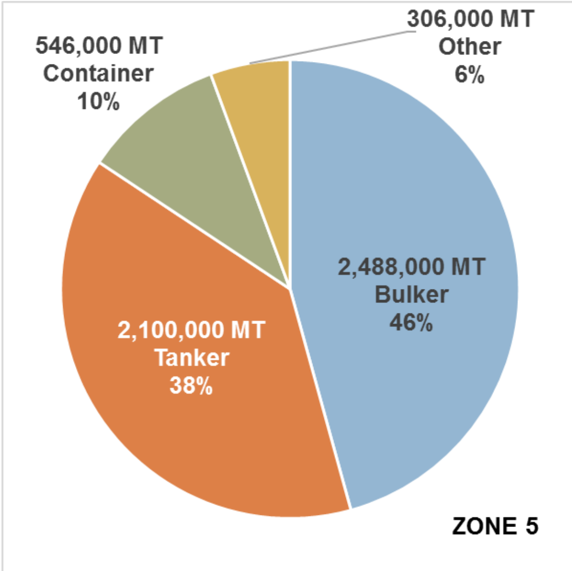


Figure 30 Annual average ballast water discharge amount by vessel type based on data from years 2011-2015, Zone 5

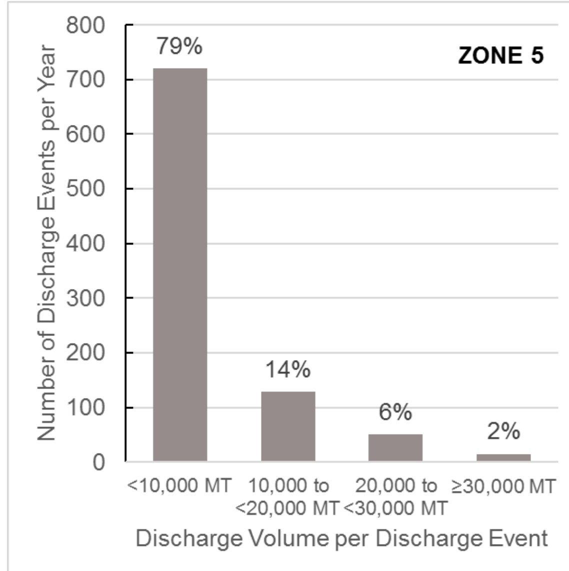


Figure 31 Average number of ballast water discharge events per year as a function of discharge amount based on data from years 2011-2015, Zone 5

The annual daily frequency of discharge events is shown in Table 16 for Zone 5. The annual distribution was determined by averaging the frequency distributions for years 2011 through 2015. On average, ninety-nine percent of the time, or on 351 days, there are six or less discharges per day in Zone 5. Seven percent of the time, or on 25 days of the year on average, there are zero discharge events in Zone 5.

Table 16 Annual average frequency of all discharge events based on data from years 2011-2015, Zone 5

Discharge Events per Day	Number of Days per Year (Cumul. Probability) based on Discharge Volume									
	All Discharges		< 10,000 MT		10,000 - <20,000 MT		20,000 - <30,000 MT		≥30,000 MT	
10	0.2	(1.00)	-		-		-		-	
9	0	(1.00)	-		-		-		-	
8	1	(1.00)	0.2	(1.00)	-		-		-	
7	3	(1.00)	1	(1.00)	-		-		-	
6	10	(0.99)	2	(1.00)	-		-		-	
5	22	(0.96)	12	(0.99)	-		-		-	
4	46	(0.90)	30	(0.96)	0.2	(1.00)	-		-	
3	81	(0.78)	65	(0.88)	2	(1.00)	-		-	
2	111	(0.55)	116	(0.70)	17	(1.00)	2	(1.00)	0.2	(1.00)
1	66	(0.25)	96	(0.38)	88	(0.95)	47	(0.99)	15	(1.00)
0	25	(0.07)	44	(0.12)	258	(0.71)	316	(0.87)	350	(0.96)

Barge Fleet Composition

The barge fleet composition for Zone 5 is shown in Table 17.

Table 17 Treatment barge fleet for Zone 5

Zone Designation	Service Area	Small Barges (10,000 m^3 service)	Mid-size Barges (20,000 m^3 service)	Large Barges (35,000 m^3 service)	Total Treatment Barges
Zone 5	Los Angeles/Long Beach and Vicinity	3	1	3	7

As can be seen from Table 16, a seven-barge system allows for a 99% probability of barge availability with one of the seven barges out of service. As can be seen in Figure 31, the majority of BW discharge events are for less than 10,000 MT, which can be serviced by any of the barges. Table 16 shows a healthy demand for the medium and large barges.

Barge Deployment

As evidenced in Figure 28 and in Figure 29, the overwhelming majority of ballast water discharge events in Zone 5 occur in San Pedro Bay (in the Ports of Los Angeles and Long Beach), or in designated anchorage areas outside the breakwater. By volume, these discharges constitute 82 percent of the annual average discharged in Zone 5. Most of the remaining discharge events are limited to the two offshore areas: El Segundo Marine Terminal and PAL. Discharges in these areas make up 18 percent of the average annual volume in Zone 5. Discharge events in other satellite areas are rare by comparison; only 10.2 events per year on average- making up just 0.1 percent of the total annual volume in Zone 5. Most of these (10 per year on average) are limited to Port Hueneme. Santa Barbara had only one reported discharge event in the last five years; and there were no reported discharges in Avalon or Morro Bay.

These data suggest that Zone 5 can, in fact, be practically served by a fleet of treatment barges, operating primarily within San Pedro Bay, with some of the barges dedicated to serving the offshore areas.

Transit distances and times between San Pedro Bay and Zone 5 satellite areas are provided in Table 18.

Table 18 Transit distances and times from San Pedro Bay to Zone 5 satellite areas

Area	Distance (nautical miles)	Transit time @ 8 knots (hh:mm)
Catalina (Avalon)	23	2:53
El Segundo/Santa Monica Bay	25	3:08
Morro Bay	200	25:00
Pacific Area Lightering (PAL)	~45	5:38
Port Hueneme	60	7:30
Santa Barbara	88	11:00

Given the range in transit times and uncertainty in the duration of ballast water discharge events, the total “out-of-zone” time for barges dispatched to satellite areas could range from 1-5 days, or even longer if back-to-back discharge events are expected. The latter scenario is most likely for El Segundo, due to regular tank vessel calls at the Chevron El Segundo Marine Terminal, which has two separate offshore berths. Given the per vessel volume of ballast water discharges at El Segundo, multi-day treatment operations would be fairly common; and considering the six-hour round-trip transit time between San Pedro Bay and El Segundo, it is reasonable to assume that treatment barges may elect to stand by for inbound vessels, rather than returning to San Pedro Bay. Conceivably, treatment barges could remain offshore for weeks at a time, operating between El Segundo and PAL, which see a combined 98 discharge events per year, on average. Most of these discharges (83%), occur in El Segundo. Therefore, it is assumed that the offshore treatment barges would be on-station primarily in El Segundo, serving PAL on an as-needed basis.

The transit distance and time between El Segundo and PAL is provided in Table 19.

Table 19 Transit distance and time between El Segundo/Santa Monica Bay and PAL

Transit Route	Distance (nautical miles)	Transit time @ 8 knots (hh:mm)
El Segundo to/from PAL	~60	7:30

Within San Pedro Bay itself (i.e. for servicing the Ports of Los Angeles and Long Beach), treatment barge transit distances and times are much shorter. The longest distance between points in San Pedro Bay (Long Beach Cruise Terminal to TraPac Terminal, Berths 136-139) is 9 nautical miles. At an assumed average towing speed of 5 knots (due to the short transit distance and the confined nature of port waterways), the transit time between these points is approximately 1.5 hours, barring any delays. Figure 32, below, shows the distribution of discharges by specific ports in the zone.

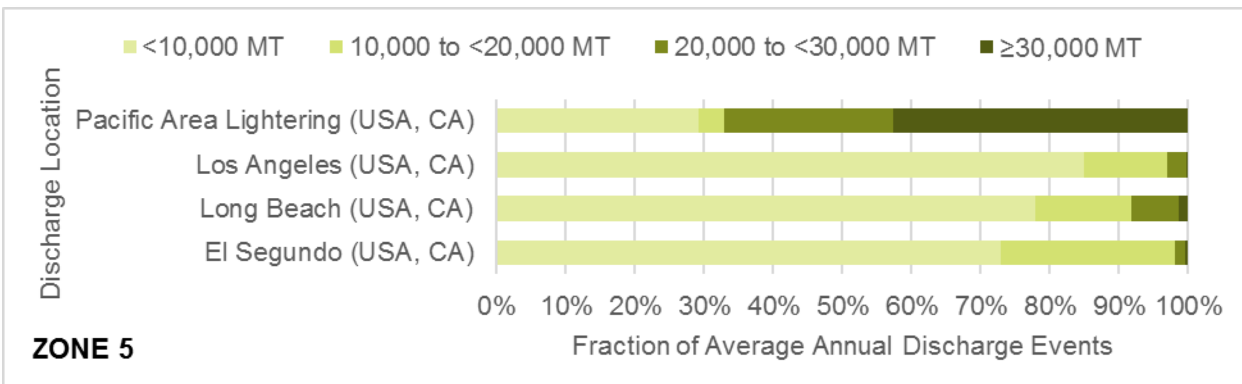


Figure 32 Average annual distribution of discharge events as a function of discharge amount per discharge location based on data from years 2011-2015, Zone 5

Zone 6 – San Diego and Point Loma

Zone 6 encompasses an approximately 21 square mile area around the periphery of San Diego Bay, including Point Loma and the eastern shore of Coronado Island. Due to the nature of shipping activity in San Diego Bay, dominated by military, general cargo, and Ro-Ro vessels carrying relatively light cargoes, ballast water discharge events in this Zone are infrequent and generally small in volume. However, considering its distance from the Ports of Los Angeles and Long Beach (~85 nautical miles) and the fact that treatment barges assigned to Zone 5 cannot be taken out of service without affecting dependability of service in that area, it was deemed impractical to serve San Diego by dispatching treatment barges from Zone 5. Instead, San Diego can be served most practically by a dedicated fleet of treatment barges.

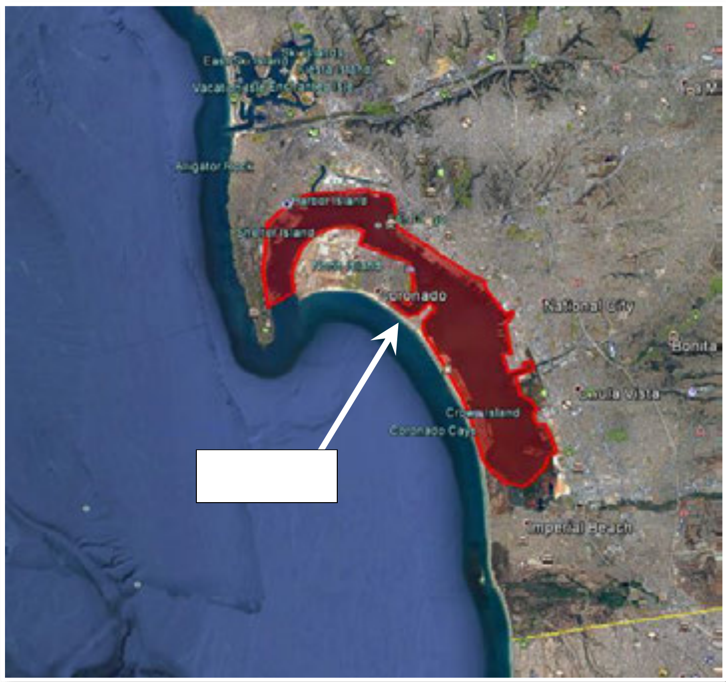


Figure 33 Zone 6 – San Diego and Point Loma

San Diego's Marine Terminals are scattered throughout San Diego Bay between Ballast Point in Point Loma and Sweetwater Channel in National City/Chula Vista. The Port handles primarily autos, refrigerated containers, bulk, and break-bulk cargoes, including windmill parts, military equipment, transformers, generators, and lumber (Reference 13). Major cargo terminals in San Diego, not including US Navy terminals and other military facilities, are the 10th Avenue Marine Terminal and National City Marine Terminal, located 3.5 nautical miles from one another on the eastern shore of the bay.

Ballast Water Discharge Activity

Ballast water discharge activity in Zone 6 is characterized by the data shown in Figure 34 and in Figure 35. Figure 34 shows the annual average ballast water discharge amount in Zone 6 by vessel type, rounded to the nearest 1,000 MT. The average is calculated based on data from years 2011 through 2015. There is a variety of vessels that discharge ballast in Zone 6, but annually, there are few discharge events. Figure 35 shows the annual average number of discharge events as a function of the amount of ballast discharged during each event. Ninety-five percent of the discharge events per year are less than 10,000 MT each.

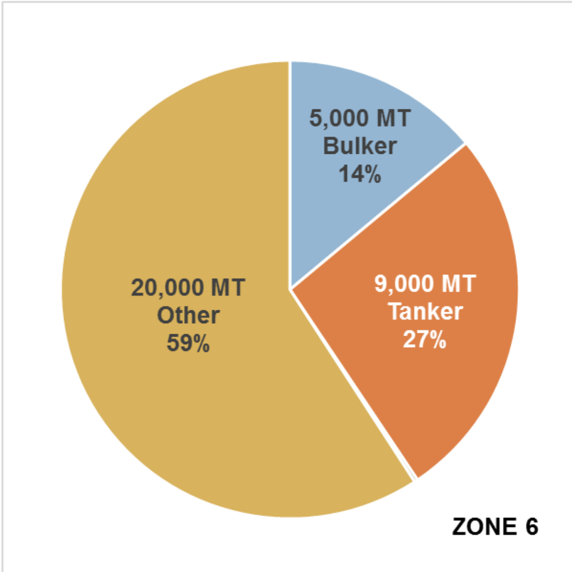


Figure 34 Annual average ballast water discharge amount by vessel type based on data from years 2011-2015, Zone 6

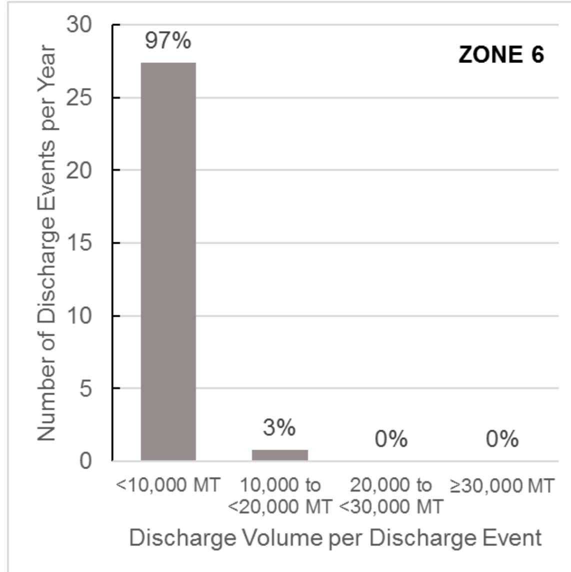


Figure 35 Average number of ballast water discharge events per year as a function of discharge amount based on data from years 2011-2015, Zone 6

The annual daily frequency of discharge events is shown in Table 20 for Zone 6. The annual distribution was determined by averaging the frequency distributions for years 2011 through 2015. On average, ninety-three percent of the time, or on 338 days of the year on average, there are zero discharge events in Zone 6.

Table 20 Annual average frequency of all discharge events based on data from years 2011-2015, Zone 6

Discharge Events per Day	Number of Days per Year (Cumul. Prob.) based on Discharge Volume									
	All Discharges		< 10,000 MT		10,000 - <20,000 MT		20,000 - <30,000 MT		≥30,000 MT	
10	-		-		-		-		-	
9	-		-		-		-		-	
8	-		-		-		-		-	
7	-		-		-		-		-	
6	-		-		-		-		-	
5	-		-		-		-		-	
4	-		-		-		-		-	
3	-		-		-		-		-	
2	1	(1.00)	1	(1.00)	-		-		-	
1	26	(1.00)	25	(1.00)	1	(1.00)	-		-	
0	338	(0.93)	339	(0.93)	364	(1.00)	365	(1.00)	365	(1.00)

Barge Fleet Composition

The barge fleet composition for Zone 6 is shown in Table 21.

Table 21 Treatment barge fleet for Zone 6

Zone Designation	Service Area	Small Barges (10,000 m^3 service)	Mid-size Barges (20,000 m^3 service)	Large Barges (35,000 m^3 service)	Total Treatment Barges
Zone 6	San Diego	2	-	-	2

As can be seen from Table 20, a two-barge system allows for a nearly 100% probability of barge availability with one of the two barges out of service. As can be seen in Figure 35, the vast majority of BW discharge events are for less than 10,000 MT, which can be serviced by any of the barges. Table 20 shows no demand for the medium or large barges.

Barge Deployment

Treatment barges in Zone 6 would operate exclusively within San Diego Bay. No satellite areas are served by treatment barges assigned to this zone. The longest expected transit distance between points in Zone 6 (National City Marine Terminal to Ballast Point) is 9 nautical miles. At an assumed towing speed of 8.0 knots, the expected transit time between these points is approximately 1 hour and 15 minutes, barring any delays.

Operational Considerations

Ballast water transfer operations and required equipment would be similar to:

- Taking on fuel-oil bunkers - for low volume flow rates on car carriers, passenger cruise ships, and some containerships.
- Discharging liquid petroleum cargo - for higher volume flow rates on bulk carriers, oil tankers, ATBs, and some containerships.

These types of transfers are common and well-documented in the bunker and oil tanker market sectors, with guidelines published by Oil Companies International Marine Forum (OCIMF), International Chamber of Shipping, and others. Some aspects of these types of vessel-to-vessel liquid transfer operations are discussed in brief here for the purposes of outlining the scope of the ballast water transfer operation.

Safety of Life and Property

Simultaneous Operations (SIMOPS)

Certain marine vessel types are required to conduct ballasting operations to offset stress and hydrostatic responses incurred during cargo operations (to maintain stability and trim). This is typical for bulk carriers, oil tankers, ATBs, and some containerships. For these vessel types, the offloading of ballast water needs to be conducted simultaneously with cargo operations, referred to as “SIMOPS” in the oil and gas industry.

The execution of SIMOPS means that vessel and shore-based crews have their attention divided between different activities, (e.g. loading containers onboard the marine vessel, while also discharging ballast water to a shore-based facility). Because these operations are different, there is risk that the operators can become distracted by one activity and lose focus on the other.

Industry response is typically to avoid SIMOPS whenever possible, given that failures can result in oil spills, injuries or fatalities, and damaged equipment. For example, oil terminals may not allow ship’s stores or fuel oil bunkers to be taken onboard concurrently with cargo operations. When SIMOPS cannot be avoided, it is typical to perform a safety risk assessment and develop a SIMOPS procedure that includes additional personnel to oversee the combined operations, in addition to the assignment of lead personnel for each individual operation.

Communications between Vessels

An critical component of successful ballast water transfer is clear communication between the vessel and the shore-based treatment barge. As the vessel’s pumps will be working in series with booster pumps on the barge, both parties must work in concert to prevent any mishaps or damage to equipment.

A pre-transfer safety conference should be conducted to establish agreement on allowable flow rates and pressures, as well as connection, start-up, and shutdown procedures. Typically, a pre-transfer checklist is used to ensure communications between the marine vessel and the facility.

Vessel Maintenance Programs

Routine Maintenance

Routine maintenance on the barges would be handled dockside during periods of inactivity. Drydockings will be required on ~30-month intervals which will require taking a barge out of service for approximately 2 weeks.

Emergency Maintenance/Repair

Emergency maintenance and repairs may require removing a barge from service. The networks are designed for such situations, while maintaining consistent reliability of service.

Contingency Plans

The barge concept designs feature double-hull construction to reduce the likelihood of an untreated ballast water spill in the event of a barge grounding, allision, or collision.

The barges will be outfitted with containment areas around key connection points and around the entire perimeter of the barge to contain inadvertent untreated ballast water spills on the barge deck.

Tug Availability

The treatment barge network would come online over a five-year period as marine vessels are outfitted with suitable ballast transfer stations. The early movements would be readily served with existing tug capacity. As the system develops, additional tug capacity will likely need to be made available to suit the increased demand.

Vessel Manning & Operation

Vessel manning is dictated by the requirements of USCG and any applicable local or state requirements. The barges would likely be crewed by personnel with similar qualifications as those serving bunker barges holding a *Tankerman Person In Charge* credential.

Similar to new training activity for new LNG bunker barges, these barges will present unique challenges that must be studied and developed into specialized training requirements. For example, crews might not fully understand the risks of spilled ballast water to the natural environment, and may require training to respond and treat such events as hazardous materials spills.

In addition to hose connection, liquid transfer, and tank loading activities that tankermen are trained for, the treatment barge will require the operation of a complex machinery plant. This operation will require additional specialized training in this equipment and any associated chemicals or other hazards.

Additional Considerations

Collection and Disposal of Filtrate

The de-sedimentation and filtration processes will result in solid and slurry wastes that must be collected and disposed so as to not present a risk to the environment. This waste cannot be discharged into the harbor or dumped offshore, as it must be assumed to contain harmful aquatic organisms and pathogens. This material must be collected, dried, and sent to shore-side landfills.

Operating Protocols and Procedures

There are numerous other topics that must be taken into consideration in developing suitable operating procedures for the transfer of ballast water between marine vessels and shore-based treatment barges. Each of these topics will require detailed study to develop ballast water-specific guidelines to ensure safe transfer. In general, it is recommended that a zero-spill, zero-incident, zero-injury operating philosophy be adopted for ballast water transfers. To achieve this, existing petroleum industry guidelines offer a logical starting point. Additional topics to be considered include, but are not limited to:

- Suitable transfer areas
- Ship-to-ship and ship-to-shore compatibility
- Metocean conditions
- Routine drills and exercises (for safety/preparedness)
- Pre and post-transfer checklists
- Actions in case of safety or security infringement
- Safe watchkeeping
- General communications
- Working language
- Initial communications between vessel and treatment barge operator
- Communications during transfer / radio protocol
- Procedures for communications failure
- Pre-transfer procedures
- Responsibility for ballast water transfer
- Planning for ballast water transfer
- Ballast water transfer requirements
- Operations after transfer is complete (post-transfer procedures)
- Documentation requirements
- Contingency planning
- Emergency signals
- Emergency procedures

Business Model/Organizational Structure

Implementation of a barge-based network in California requires a business model that balances the competing needs of: a) supporting existing commerce patterns; and, b) ensuring investment of significant capital and time into this new and uncertain market. If the resulting fees to vessel operators are too high or imbalanced, it could result in the diversion of marine commerce away from California in general, or a shifting of vessel activity from small or remote California ports to larger ones with lower overall port call costs. Investment capital and time is at risk due to the potential for political pressure to delay or even cancel implementation, and dependence on the marine vessels themselves to install specialized ballast transfer stations to support ballast water transfer operations.

There are many potential models that could support a barge-based ballast water treatment service in California. This section first outlines various common structures used in the marine and other businesses. It then suggests a variation of a public-private partnership (PPP) as a possible structure that could support state and private objectives. It should be noted, however, that additional research beyond the scope of this study is recommended to identify an optimal business model/organizational structure.

Overview of Business Models

For-profit Companies

For-profit companies are private entities governed by a Board of Directors or owners that have the general mission to maximize the company's value to its owners. Unless otherwise required, rate-setting and the distribution of revenues are proprietary and based on the company's consideration of anticipated expenses, capital expenditures, and what the market will bear. Rates may therefore be set based on market demands and a party's willingness to pay (Reference 6).

Starting a for-profit company does not require any enabling legislation, but the company will be subject to federal, state, and possibly local taxes so revenues must be sufficient to meet those obligations as well as other expended while satisfying owners' expectations for profit gained (Reference 6).

Non-profit Companies

For nonprofit organizations, a Board of Directors and/or the organizations' members govern, but do not own, the entity. Nonprofits may obtain tax-exempt status with the federal or state (or local) government, but still retain most of the flexibility of any private corporation (in contrast to a port authority or utility, whose operations and rates are more closely controlled by government) (Reference 6).

Nonprofit organizations must exist primarily to serve a public good and must meet certain requirements in that they establish budgets, handle revenues, set rates, and share information in order to obtain and sustain their tax-exempt status. Revenues that exceed expenditures must be reinvested into the organization, rather than distributed to its members (Reference 6).

Members of nonprofit organizations can participate in the organization either by serving on the Board of Directors or by electing members to that board, or, if included in the bylaws, voting on an annual budget or other key decisions (Reference 6).

Dues or fees paid by members are the primary source of revenues for operating and must be charged to members or those using the services according to a transparent structure that applies to all paying members. Although dues must be charged fairly, there can still be a tiered structure such that vessels of different types or sizes, for example, are charged different amounts. Nonprofits may also be eligible for grants from government agencies or private foundations (Reference 6).

Cooperatives

Cooperatives represent a third model that may be applied to mobile, barge-based ballast water treatment services. A cooperative is owned by and operated for the benefit of those using the services. The profits and earnings generated by the cooperative are distributed among the members, also known as user-owners. Typically, an elected Board of Directors runs the cooperative, while regular members have voting power to control its direction. Members can become part of the cooperative by purchasing shares, though the amount of shares they hold does not affect the weight of their vote (Reference 6).

To begin a cooperative, a group of potential members must agree on a common need and a strategy on how to meet that need. If a cooperative chooses to incorporate they must file articles of incorporation, create bylaws, create membership applications to recruit members, conduct charter member meetings and elect Directors, obtain licenses and permits, and hire employees (Reference 6).

Similar to nonprofits, cooperatives are not taxed on surplus revenues; but, unlike nonprofits, they refund revenue to their members. Cooperatives are also typically eligible for funding opportunities through government grants. However, relying on member contributions makes cooperative cash flow subject to the extent to which their members use or value the service they provide. Also, if members do not fully participate and perform their duties, whether it be voting or carrying out daily operations, then the business cannot operate at full capacity and risks losing members (Reference 6).

Port Authority

While not commonly used for tug and barge operations, this business model represents a potential approach to collecting fees and applying those fees to build and operate a localized system, similar to the barge service networks introduced in this report (Reference 6).

A port authority is a quasi-public entity that is usually established through enabling legislation or local ordinance. Although it is governed by an independent board (as opposed to operated by government employees as a public agency), it is essentially owned by the government (Reference 6). Financially, a port authority operates in a manner similar to a non-profit in that the focus is primarily on recovering the costs of providing services, rather than generating profit, through reserves can be accrued.

Utilities

Utilities are typically established by a statutory framework to provide a particular service, such as power or water services. The actual business model used will vary, but utilities are heavily regulated by state government, including the government’s oversight of rate setting. They are typically created through enabling legislation (Reference 6).

Public-Private Partnership Alternative

The World Bank describes PPPs as “a mechanism for government to procure and implement public infrastructure and/or services using the resources and expertise of the private sector.” It goes on to note that PPPs are used to share risk and allows the government to benefit from the expertise of the private sector.

The barge-based network may fit this model. The cost of investment is high, producing many new costly barges and treatment plants for a new and uncertain market. The service is a public good to meet state treatment standards. It does not seem likely that the state will build and operate its own fleets of service barges.

It should be noted that some zones, in particular Zone 6 San Diego, would be very difficult to run commercially given very high idle times (338 days/year with zero discharges). It is likely that these would need to be highly subsidized to avoid extremely high charges on those 27 days of usage.

This sub-section discusses the objectives for such a partnership, presents the Design, Build, Operate (DBO) variation, and outlines how a licensing agreement could serve the state's needs.

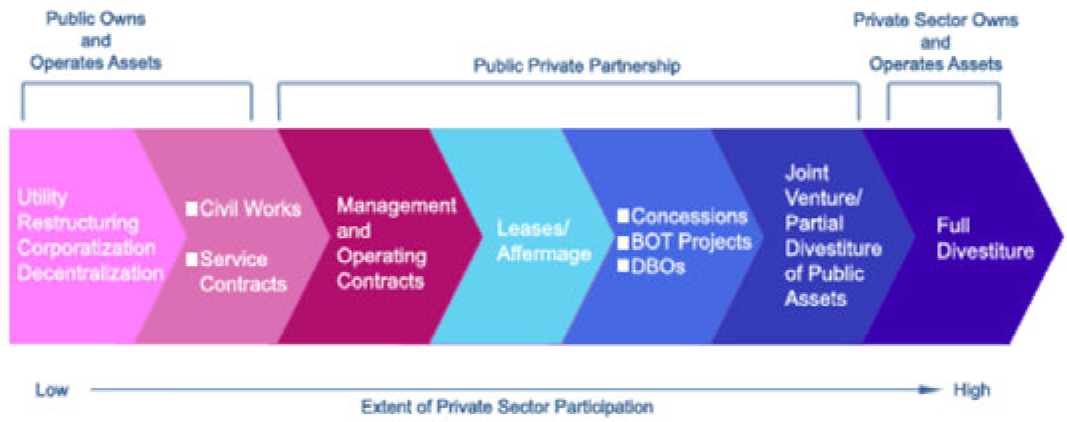


Figure 36, Spectrum of PPP Agreements (World Bank, 2017)

Structure Objectives

The overall structure objective is to develop and provide a service that will ensure that ballast water discharged in California meets the state's interim treatment standards, and thereby protecting the environment from potential aquatic invasive species and pathogens. Within this overall objective, California and private operators will have different objectives and different areas of risk sensitivity. Understanding these are critical to developing a suitable structure.

The State, among others, has the dual objectives of supporting commerce and protecting the environment. Some key considerations include:

- Ensuring that the barge-based network is quickly and effectively implemented.
- Ensuring that treatment standards are consistently met.
- Avoidance of disadvantaging small ballast volume and/or remote port districts with disproportionate costs for a ballast water service.
- Avoidance of losing existing commerce due to increased or new vessel fees, new ship-based hardware, ship delays due to ineffective service, or other

A private partner will have multiple objectives as well, including:

- Minimizing capital investment risk in a market with regulatory uncertainty.
- Ensuring market share, number of ships to be serviced, so that projected revenues and profits are reasonable.
- Ensuring compliance with regulatory requirements.

There are additional stakeholders as well. These objectives are broadly captured in those of the State and private partner. They are rephrased here from those stakeholder points of view.

- Environmental advocates are seeking the highest reliability in meeting the CA Interim Standards as soon as possible, in addition to minimizing other ancillary impacts such as air pollution and secondary effluents.
- Marine vessel operators are seeking a robust and reliable service that does not place personnel or equipment in harm's way, does not result in undue delay to operations, minimizes new operations, and keeps new costs to a minimum.
- State regulatory agencies are seeking a robust program that is easy to monitor and assure compliance with the requirements.

DBO Variation

Under the Design, Build, Operate (DBO) variation, California would finance the capital investment with private companies designing, building, and operating a fleet of service barges in one or more zones. This would serve the objectives of minimizing the private partner risk of investing in an uncertain market, and the State's objective of providing a functional and resilient service network.

Ownership of the barges and assets would depend on the terms of the financing. It seems unlikely that the State would want ownership of the treatment barges long term. While it might be possible for the State to provide such barges to another operator, such a transfer is uncommon. More likely, the agreement would follow a guaranteed loan arrangement, especially given that the individual barge asset is in the range of $5 to $15 million.

Licensing Agreement

The PPP would require a licensing agreement that offers the private company exclusive access to its serviced zone(s). This would protect the joint investment and provide California a mechanism to control fees and potentially support disadvantaged port districts.

Some aspects that the license agreement might consider are:

- How is performance measured? Is the service providing timely ballast water reception with minimal delays? Are spills, incidents, and downtime minimized?
- How is the tariff structured that passes the costs to the ship operator? Does this provide an incentive for efficient and effective service from the licensee? Does this disproportionately impact remote port districts that might need to pay a higher tariff to offset low equipment utilization and/or transportation costs?
- How is the investment split? In particular, would the State offer berth areas as part of the license or finance the licensee's investment?

The barge-based aspect of such an arrangement offers some opportunities to provide performance and innovation incentives by the private party. These following might be considered:

- Given the six discrete service networks, it is possible to have several concessionaires offering similar services. While this wouldn't be direct competition, it would offer some ability to compare service performance between providers. In addition, such an arrangement could foster innovation.

- While the barge investment costs are high, they are not as high as land-based infrastructure such as large pipelines. This offers the possibility that the concession term could be for a shorter duration such as five years, rather than a typical public utility concession of 25 years or more. This shorter term could increase incentives for efficiency and performance, and the ability to adjust contracts when they are up for renewal.

Taxes and Fee Rates

The PPP model provides the opportunity for the licensee to provide an income stream to the state for the rights to provide a service for fee. Under this model, the licensee would directly charge the marine vessels that it services. This fee would be part of a competitively bid or negotiated rate with the state. A fee schedule might consider:

- Revenue required to cover private partner costs, profit, and payments to the state for the license.
- Fee based on combinations of:
  - Call-out to provide service, time alongside offering services, and quantity of ballast water processed.
  - Type of vessel, discharge rate requiring larger and more expensive barge, special handling requirements such as gas hazards with tank ship ballast water.
  - Offsets mandated by the state, such as reductions for remote ports or other considerations.

Port Competitiveness

The cost competitiveness of ports has the potential to shift vessel activity and cargo movements between locations, both within and external to California. In other words, ship operators carrying "discretionary cargo" – i.e. cargoes not destined for local consumption - would generally prefer to call a port with lower overall costs than a similar port with higher overall costs. In the case of ballast water, this has the potential to adversely impact port districts that are geographically isolated or see infrequent ballast water discharges.

A licensee that must transport a barge to a remote location would typically charge the ship operator for that additional transportation cost, i.e. tug and barge day rates and fuel surcharges for equipment mobilization and demobilization. A licensee that must operate a barge network in a low utilization area, such as Zone 4 with ~280 days with zero discharges or Zone 6 with ~340 days with zero discharges, would need to charge higher fees per unit of water discharged to cover the periods of inactivity.

In the contracting arrangement, the state might consider models where the licensee must charge the same rate regardless of location within a particular zone. In some areas, the state might need to pay the licensee to maintain service in locations that might otherwise see reductions in vessel activity as a result of high ballast water reception and treatment fees. One potential drawback to this is that this could be considered a tax on lower cost areas to pay a subsidy for high cost areas (which may be non-competitive for other reasons). Nevertheless, it may be necessary to keep ballast water reception costs from adversely impacting certain port districts.

Certainty and Convenience to Ship Operators

The addition of any new service to ship operators decreases certainty and convenience. The treatment barge could arrive late or not arrive; and when it does arrive, it requires ships' crews to make the connections/disconnections and oversee the operation. This means that port calls will take longer and be more expensive. Furthermore, the marine vessel will now be more restricted in its movements, in particular with a treatment barge moored alongside. This can be problematic when attempting to receive other barge or supply vessel-based services such as delivery of lubricants, bunkers, cargo, or stores.

Noting the above concerns, it is possible to provide reliable treatment barge service, but this will depend on the concessionaire and government oversight of that service. Additionally, it is reasonable to assume that treatment barges can be secured alongside commercial ships and other marine vessels, given that this is current practice for other services.

Compliance/Effectiveness Monitoring and Enforcement

Treatment barge effluent will need to meet a combination of State Water Resources Control Board, US EPA, and California State Lands Commission requirements.

It is possible that the barges could be permitted under the National Pollution Discharge Elimination System (NPDES), as they are unlikely to meet certain Water Board requirements, such as dissolved solids, and therefore need acceptance of the planned effluent. For example, a treatment barge servicing a ship discharging seawater ballast will not be able to remove the dissolved salt from the captured ballast water.

The focus of the treatment barges is removing aquatic invasive species and potentially harmful pathogens from discharged ballast water to the CA Interim Standards. Most ballast water evaluation and monitoring technology has been developed based on required detection limits to suit the USCG standard that is less challenging to meet. That noted, some methods do have a limit of detection ten-times lower than the USCG standard. It is expected that the treatment barge discharges will be monitored routinely with the latest equipment and methods, providing the lowest limits of detection practical.

It is unclear how effective the state can be in enforcing the use of the treatment barges. Ballast water discharges are often below the ship's waterline, and therefore invisible to the casual observer. However, it is assumed that California State Lands and USCG would continue their outreach programs to board and educate vessel operators on the requirements. If needed, these bodies could also serve as enforcement authorities.

Conclusions

A network of ballast water treatment barges offers significant advantages for the practical implementation of shore-based ballast water treatment in California. A network of six discrete treatment zones is proposed as one feasible means of implementation. A public-private partnership model should be considered as a means of incentivizing private investment in the barge network, while meeting the State's dual objectives of protecting the environment and promoting commerce. Further research is needed to determine an optimal network design and sustainable business model.

Appendix A Study Overview and Definitions

Study Overview

Marine vessels routinely uptake ambient sea or harbor water as ballast, transit to another port, and then discharge that ballast water. Unfortunately, the resulting ballast water discharges have been linked to the introduction of aquatic invasive species and harmful pathogens. In an effort to reduce or possibly eliminate further introductions, marine vessels are being required to manage ballast water discharges by a myriad of international, federal, and regional guidelines and rules. Vessels discharging in California will be required to meet an interim standard that is more stringent than international and US federal standards.

In response, there has been significant development work and commercial installations of ballast water management systems (BWMS) onboard marine vessels themselves. However, there is a lack of data to determine if shipboard BWMS are capable of meeting the CA Interim Standards. Therefore, shore-based ballast water reception and treatment is under consideration as an approach to meet the CA Interim Standards.

This study evaluates the feasibility of shore-based ballast water reception and treatment in 13 separate tasks, beginning with a review of shore-based treatment research, followed by a series of detailed analyses, including: permitting and legal requirements, detailed cost estimates, timeline to implementation, and market implications.

Tasks Overview

Tasks 6 through 13 are submitted together to discuss the practical implementation of shore-based ballast water reception and treatment throughout California state waters, accomplished by a "network" of six (6) independently operating fleets of mobile treatment barges (see Table A-1).

During the course of this study, following completion of Tasks 2-5 and the comparative scale-up exercise described in Reference 7, this approach was deemed most technically, operationally, and financially feasible of the five approaches that were evaluated (i.e. new onsite treatment facility, new offsite treatment facility, existing wastewater treatment facility, shore-side mobile treatment, mobile marine vessel-based treatment).

Table A-1 Tasks 6 through 13

Task	Description
6	Assessment of construction related to outfalls for treated ballast water discharges, and provision for disposal of solids as needed.
7	Summarize pertinent permitting and legal requirements.
8	Comparative review of shipboard vs. barge-based ballast water management operations.
9	Assessment of current practices related to ballast water discharges in California.
10	Cost analysis.
11	Implementation timeline.
12	Market implications.
13	Other analysis and findings. Introduces the concept of a statewide network of mobile treatment barges for the provision of ballast water reception and treatment services across the state, and forms the basis for assessments and analyses in Tasks 6-12.

Definitions

ABS	American Bureau of Shipping
ANSI	American National Standards Institute
ASTM	An international standards organization.
ATB	Articulated Tug Barge
AWL	Height Above Waterline
AWWA	American Water Works Association
Ballast Water	Water taken on by a ship to maintain stability in transit.
Ballast Water Exchange	The process of exchanging a vessel's coastal ballast water with mid-ocean water to reduce concentration of non-native species in accordance with regulatory guidelines.
Ballast Water Management	The entire process of treatment and handling of a ship's ballast water to meet regulatory requirements and prevent spread of non-native species.
BMPF	Ballast Manifold Presentation Flange
Booster Pump	Pump, typically centrifugal, that adds additional pumping force to a line that is already being pumped.
BWDS	Ballast Water Discharge Standards
BWE	Ballast Water Exchange
BWM	Ballast Water Management
BWMS	Ballast Water Management System
BWTP	Ballast Water Treatment Plant
BWTB, BWT Barge	Ballast Water Treatment Barge
BWTS	Ballast Water Treatment System
Capture	Capture is the method by which ballast water is transferred onto or off a marine vessel.
CD	Chart Datum
CFU	Colony Forming Units
CMSA	California Marine Sanitation Agency
DAF	Dissolved Air Floatation
DIN	Deutches Institut für Normung (German Institute for Standardization)
Discharge	Discharge of ballast water is the method by which post-treatment ballast water is disposed of in compliance with applicable standards and regulations.
DOC	Dissolved Organic Carbon
DWT	Deadweight Tonnage
EPA	Environmental Protection Agency (US, unless otherwise noted)
Filtrate	Water that has been separated from any particulate matter (used to clean ballast water treatment filters).
GA	General Arrangement
GM	Metacentric height (a measure of a ship's stability).
gpm	Gallons per minute. Any measurements quoted in gallons of ballast water per minute will also be shown in MT of ballast water per hour, or MT/h.

HDPE	High-density Polyethylene
IMO	International Maritime Organization
ISO	International Organization for Standardization
JIS	Japanese Industrial Standards (organization)
L	Liter
Lift Station	Means of receiving a liquid, typically from a drain or low-pressure piping, and ‘lifting’ it with pump(s) to a different location such as a remote tank.
Lightering	Cargo transfer between vessels, commonly practiced to reduce a vessel’s draft before entering port.
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
MARPOL	International Convention for the Prevention of Pollution from Ships
MF	Microfiltration
mg	Milligram
MG	Millions of gallons. Any measurements quoted in MG of ballast water will also be shown in MT of ballast water.
MGD	Millions of Gallons/Day
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
MPA	Megapascal (unit of pressure)
MSL	Mean Sea Level
MT	Metric tons. One cubic meter of seawater is roughly equivalent to 1.025 MT, but this value varies depending on temperature and salinity of the water. In this report, conversions between volume and weight of seawater are merely approximate and assume 1 m3 of seawater has a mass of roughly 1 MT, for convenience.
Navy Mole	A man-made peninsula in the Port of Long Beach that flanks entrance to the middle and inner harbor
NBIC	National Ballast Information Clearinghouse
NOM	Natural Organic Matter
Non-native Species	Species that are not indigenous to a particular region. Non-native species can be introduced to marine ecosystems through a ship’s ballast water. “Invasive” species are non-native species with the potential to cause harm to the environment or human health.
NPDES	National Pollution Discharge Elimination System
NTU	Nephelometric Turbidity Unit
NYSERDA	New York State Energy Research and Development Authority
O&M	Operations and Maintenance (cost)
OCIMF	Oil Companies International Marine Forum
POTW	Publicly Owned [Wastewater] Treatment Works
PSU	Practical salinity units.
Residuals	Particulate matter collected from cleaning ballast water treatment filters.
ROM	Rough Order of Magnitude (cost)

Ro-ro	Roll-on/roll-off (vessels designed to carry wheeled cargo such as car, trucks, trailers, and equipment)
RWCF	Regional Wastewater Control Facility (e.g. City of Stockton, CA)
Shipboard Ballast Water Treatment	Ballast water management approaches that do not require support from shore-based infrastructure and are conducted entirely by a vessel's crew.
Shore-Based Ballast Water Management	Ballast water management approaches that require support from shore-based infrastructure in order to meet ballast water management requirements. Such infrastructure may include: means of transferring ballast water to a land-based or another marine vessel facility for storage and/or processing, deployment of shore-based equipment and personnel for onboard treatment approaches, etc.
Slurry	Mixture of filtrate and filter residuals resulting from cleaning ballast water treatment filters.
Slurry Handling	Slurry handling includes activities related to the storage, treatment, and discharge of filtrate and residuals collected from cleaning ballast water treatment filters.
SOLAS	International Convention for Safety of Life at Sea
Storage	Storage of ballast water includes provision of space and containment for ballast water, either pre-or post-treatment.
STS	Ship-to-Ship. Transfer from one marine vessel to another.
TDS	Total Dissolved Solids
TEU	Twenty-foot Equivalent Unit
TOC	Total Organic Carbon
Transfer	Ballast water transfer considers the logistics and equipment required to capture the ballast water from the marine vessel and transport to a reception and treatment facility.
Transport	Transport is the method by which ballast water is moved post-capture from marine vessels to remote, non-mobile reception and treatment facilities – either land-based or otherwise.
Treatment	Treatment includes the various methods to process ballast water such that it is suitable for discharge in compliance with applicable standards and regulations.
Treatment Approach	A general method for implementing ballast water treatment. Treatment approaches may include mobile systems, land-based facilities, shipboard systems, etc.
Treatment Technology	Specific techniques for removal or inactivation of organisms in ballast water (e.g., UV disinfection, filtration, ozonation, etc.)
TRO	Total Residual Oxidant
TSS	Total Suspended Solids
UF	Ultrafiltration
UKC	Underkeel Clearance
UL	A global independent safety consulting and certification company (formerly Underwriters Laboratories).
USCG	United States Coast Guard
UV	Ultraviolet Light
UVT	UV Transmittance
VLCC	Very Large Crude Carrier

WWTF	Waste Water Treatment Facility
WWTP	Waste Water Treatment Plant